



National Aeronautics and Space Administration



UAS Integration in the NAS Project FY15 Annual Review

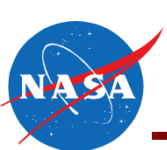
Laurie Grindle
Project Manager

Debra Randall
Chief Systems Engineer

Davis Hackenberg
Deputy Project Manager, Integration

October 27, 2015

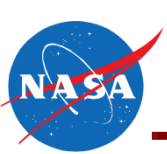




Agenda



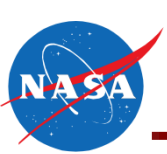
8:00 – 8:30	Welcome, Opening Remarks	Ed Waggoner
8:30 – 9:15	UAS-NAS Overview	Laurie Grindle
9:15 – 10:30	Technical Challenge Performance	Debra Randall
10:30 – 10:45	Break	
10:45 – 11:50	Non-Technical Challenge Work Project Processes Implementation	Davis Hackenberg
11:50 – 12:30	Project Level Performance & FY16 Look Ahead Review Summary	Laurie Grindle
12:30	Lunch	
1:00 – 3:00	IRP/PRP Caucus	
3:00 – 4:00	IRP/PRP Initial Feedback	
4:00	Adjourn	



Annual Review Overview



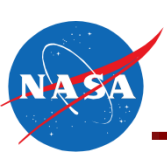
- Purpose - Conduct an assessment of the Project's quality and performance
- Approach - The Project will provide a programmatic review addressing the following:
 - Project's Goal and Technical Challenges (TC) and their alignment to NASA and ARMD Strategy
 - Project background and alignment with community efforts
 - Key highlights and accomplishments for the Project's technical challenges
 - Project performance of the past year through examination of:
 - Cost/Resource, Schedule, and Technical Management
 - Progress in establishing partnerships/collaborations and their current status
 - Key activities, milestones, and “storm clouds” for FY16
 - Specific Topics; for each of the following describe:
 - Assessment of programmatic rigor and the balance with quality and performance
 - LVC-DE state of the art capability, FY15 work towards enhancements, and future benefit
 - Resources necessary to complete planning for potential additional Project phase
 - FY15 progress towards assessment of UAS full integration and near term next steps



Outline



- UAS Integration in the NAS (UAS-NAS) Overview
 - FY15 Summary
 - UAS-NAS Project Background
- Technical Challenge Performance
- Non-Technical Challenge Work
- Project Processes Implementation
- Project Level Performance & FY16 Look Ahead
- Review Summary

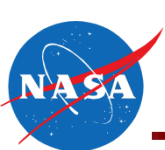


FY15 Summary



- Successful execution of Project Phase 2 Portfolio
 - Executed multiple ground tests, simulations, and flight tests
 - FY15 Annual Performance Indicator (API)
- Balanced rigor with timely and effective project management
 - Incorporating process lessons learned
- Enhanced LVC distributed test environment with augmentation spending
- Integral member of RTCA SC-228

***Delivered research findings and subject matter expertise
integral to DAA and C2 Preliminary MOPS***



NASA Strategic Plan Flow Down to UAS-NAS Project



STRATEGIC GOAL

2: Advance understanding of Earth and develop technologies to improve the quality of life on our home planet

OBJECTIVE

2.1: Enable a revolutionary transformation for safe and sustainable U.S. and global aviation by advancing aeronautics research

PERFORMANCE GOAL UAS-NAS

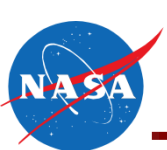
2.1.6: Support transformation of civil aircraft operations and air traffic management through the development, application, and validation of advanced autonomy and automation technologies, including addressing critical barriers to future routine access of Unmanned Aircraft Systems (UAS) in the National Airspace System, through the development and maturation of technologies and validation of data.

Annual Performance Indicators (APIs) UAS-NAS

AR-15-7: Deliver data, analysis, and recommendations based on integrated simulations and flight tests to the RTCA Special Committee on Minimum Operational Performance Standards (MOPS) for UAS to support preliminary MOPS development.

* **AR-16-8:** Deliver data, analysis, and recommendations based on integrated simulation and flight test series with simulated traffic or live vehicles to the RTCA Special Committee on MOPS for UAS to support development of the final MOPS.

* Revised based on current OCFO submission



ARMD Strategic Plan Flow Down to UAS-NAS Project



AERONAUTICS STRATEGIC THRUST

Thrust 6: Assured Autonomy for Aviation Transformation

AERONAUTICS OUTCOME

Outcome (2015 – 2025): Initial Autonomy Applications
with Integration of UAS into the NAS

UAS-NAS Project Goal

Goal: Provide research findings to reduce technical barriers associated with integrating Unmanned Aircraft Systems into the National Airspace System utilizing integrated system level tests in a relevant environment

UAS-NAS Research Themes

Research Theme 1: UAS Integration - Airspace integration procedures and performance standards to enable UAS integration in the air transportation system

Research Theme 2: Test Infrastructure - Test infrastructure to enable development and validation of airspace integration procedures and performance standards

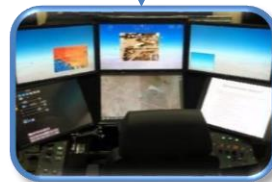
UAS-NAS Technical Challenges



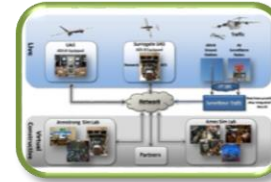
TC-C2:
*Command & Control
Performance Standards*



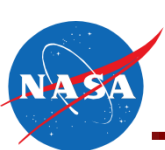
TC-SAA:
*Sense and Avoid
Performance Standards*



TC-HSI:
*Human Systems
Integration*



TC-ITE:
*Integrated
Test & Evaluation*



UAS Integration in the NAS Organizational Structure



Host Center

AFRC Director of Programs
Dennis Hines
Deputy Director: Joel Sitz

Program Office

IASP Program Director
Dr. Ed Waggoner
Deputy PD: Lee Noble (acting)

*ExCom, RTCA Steering
Committee, UAS
Aviation Rulemaking
Committee*

Project Support

Lead Resource Analyst – Cindy Brandvig - AFRC
Lead Procurement Officer – R. Toberman - AFRC
Lead Scheduler – John Percy - AFRC
Mgmt Support Specialist– Jamie Turner - AFRC
Administrative Support – Giovanna Bowen - AFRC
Bus. Sys. Coordinator – Stacey Jenkins - AFRC

Project Office

Project Manager - Laurie Grindle - AFRC
Deputy Project Manager – Robert Sakahara – AFRC
Deputy Project Manager, Integration – Davis Hackenberg - AFRC
Chief Systems Engineer – Debra Randall – AFRC
Deputy Chief Systems Engineer – Peggy Hayes - AFRC
Staff Systems Engineer – Dan Roth – AFRC

External Interfaces

*FAA, DoD, RTCA SC-228,
Industry, etc.*

DPMf – AFRC
Heather
Maliska

DPMf – ARC
Matt
Knudson

DPMf – GRC
Mike
Jarrell

DPMf – LaRC
Vince
Schultz

AFRC ARD
ARC ARD
GRC ARD
LaRC ARD

Technical Challenges (TC)/Subprojects

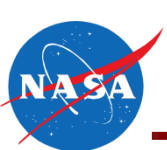
**TC-C2: C2 Performance
Standards**
Communications
PE
Jim Griner - GRC

**TC-SAA: SAA Performance
Standards**
Separation
Assurance/Sense and Avoid
Interoperability (SSI)
Co-PEs
Confesor Santiago - ARC
Keith Arthur - LaRC

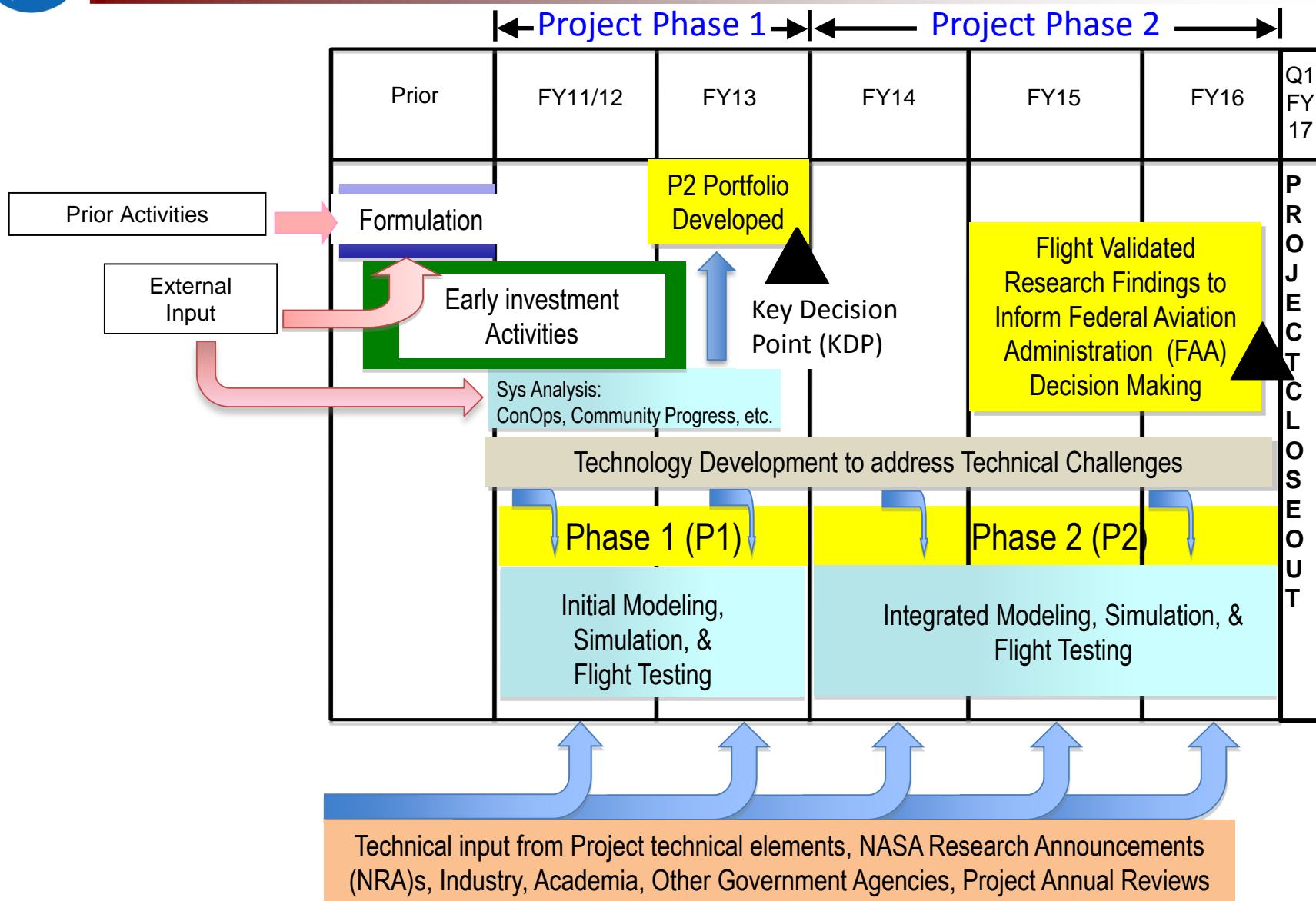
**TC-HSI: Human Systems
Integration (HSI)**
HSI
PE
Jay Shively - ARC

**TC-ITE: Integrated Test and
Evaluation (IT&E)**
IT&E
Co-PEs
Sam Kim - AFRC
Jim Murphy - ARC

Certification
PE
Kelly Hayhurst
LaRC



UAS-NAS Project Lifecycle

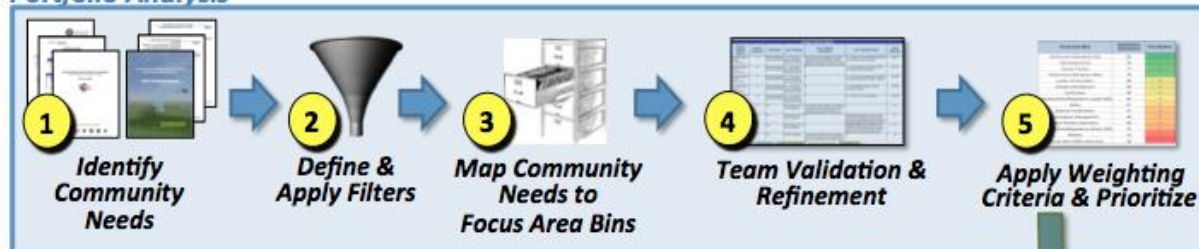


Timeframe for impact: 2015 - 2025

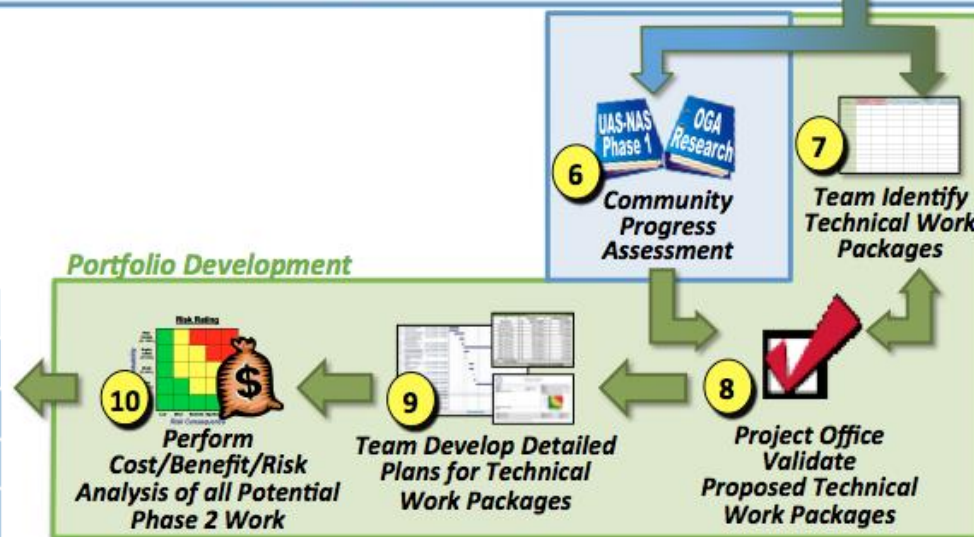
Community Needs Influence on Project Phase 2 Portfolio and Technical Challenges

- Phase 2 Content Decision Process (CDP) included an evaluation of the technical needs of the UAS Community
- Resultant prioritized list, and Community Progress Assessment, of Focus Area Bins served as the foundation for Phase 2 Portfolio and Technical Challenges
- Technical Challenges, Technical Work Packages, and detailed executable Schedule Packages were evaluated using a cost/benefit/risk process to determine the final portfolio

Portfolio Analysis



Portfolio Development



Phase 2 Portfolio

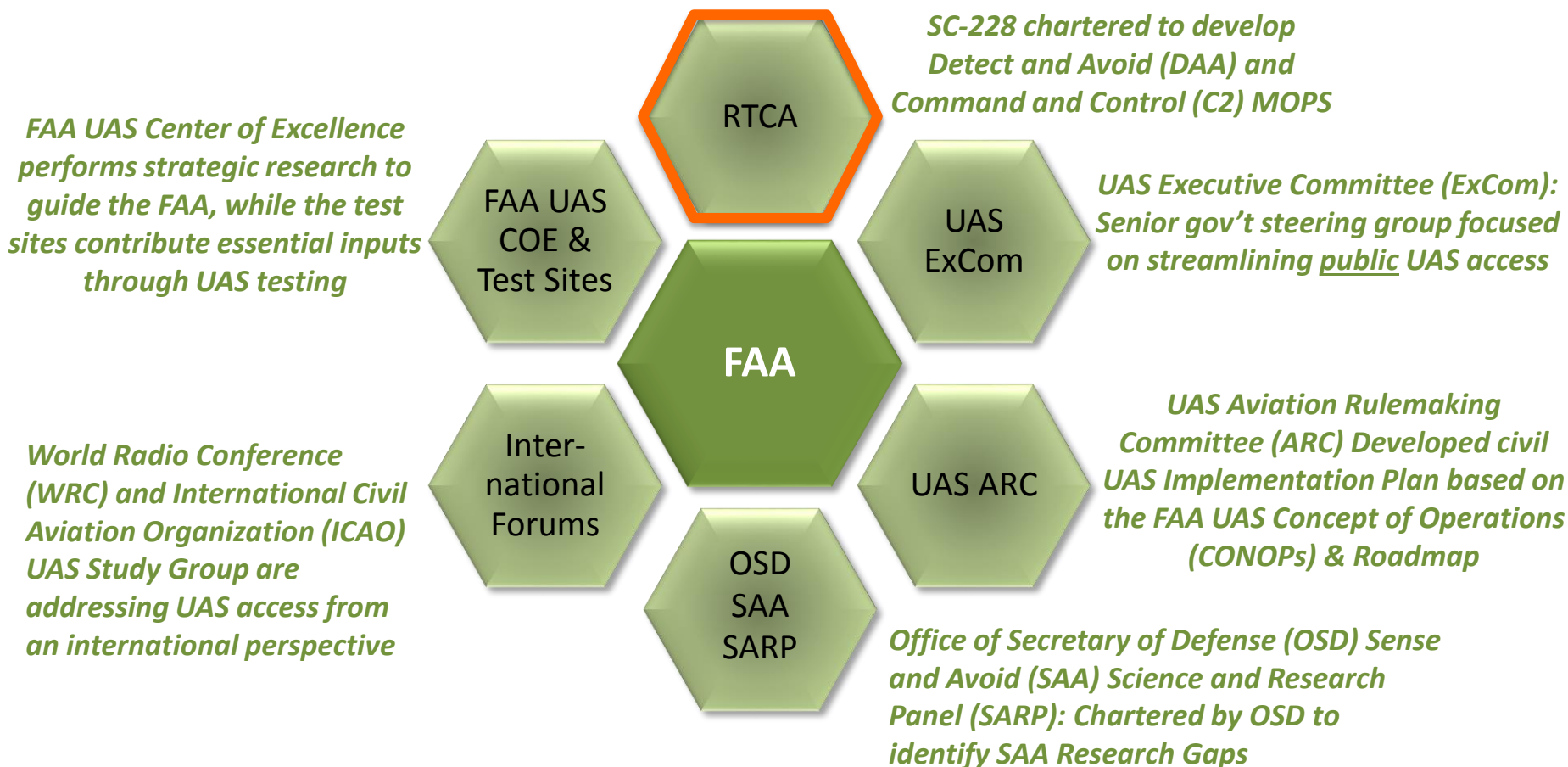
Technical Challenges (TC)

Technical Work Packages (TWP)

Schedule Packages (SP)

Tasks

- The FAA is using several domestic forums, in conjunction with several international forums to lay out the pathway for their priorities and investments.



NASA has a leadership role within many domestic forums and participates in the international forums

RTCA SC-228 Terms of Reference (ToR) has defined a path forward to develop Minimum Operational Performance Standards (MOPS)

- Phase 1 MOPS are addressed by UAS-NAS Current (FY14 – FY16) Portfolio
 - Command and Control (C2) Data Link MOPS – Performance Standards for the C2 Data Link using L-Band Terrestrial and C-Band Terrestrial data links
 - Detect and Avoid (DAA) MOPS – Performance standards for transitioning of a UAS to and from Class A or special use airspace, traversing Class D and E, and perhaps Class G airspace
- SC-228 Deliverables
 - C2 & DAA White Papers (Dec 2013) - Assumptions, approach, and core requirements for UAS DAA and C2 Equipment
 - C2 & DAA MOPS for Verification and Validation (July 2015) – Preliminary MOPS Including recommendations for a Verification and Validation test program
 - C2 & DAA MOPS (July 2016) – Final MOPS

RTCA Paper No. 100-13/PMAC-1089
May 20, 2013

TERMS OF REFERENCE
RTCA Special Committee 228
Minimum Performance Standards for Unmanned Aircraft Systems

REQUESTORS:

Organization	Person
AVS	Jim Williams

SPECIAL COMMITTEE LEADERSHIP:

Position	Name	Affiliation	Telephone	email	Change
Co-Chair	George Ligter	Consultant to PMEI	301-983-4388	gligter@pmei.com	(list to change in name)
Co-Chair	Paul McDuffee	Insitu Inc.	208-493-6409	paul.mcduffee@insitu.com	
DFO	Steve Van Trees	FAA	202-385-4635	stephen.vantrees@faa.gov	
Secretary	Gary Furr	Engility Corporation	800-485-4254	Gary.c.furr@faa.gov	

BACKGROUND:

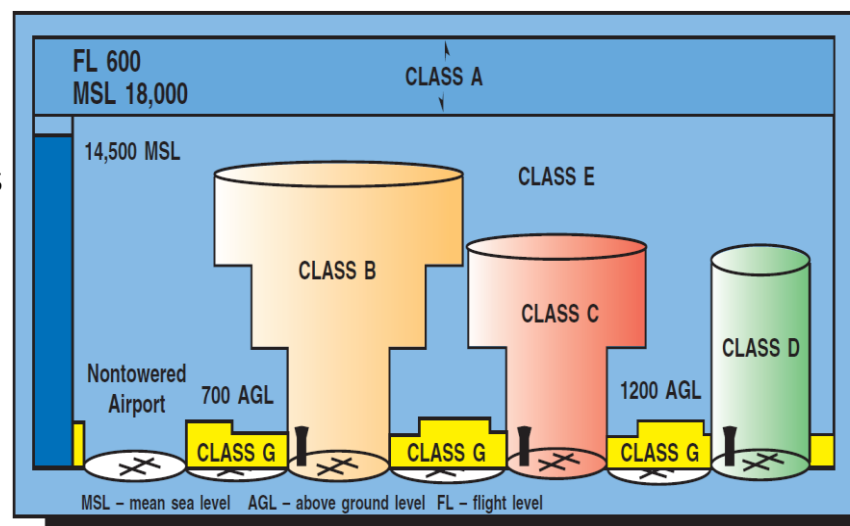
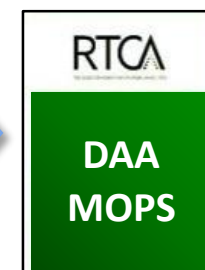
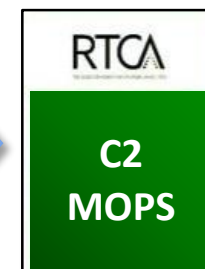
Unmanned aircraft have the potential to allow civil, public, commercial, and government agencies to increase efficiency, save money, enhance safety, and even save lives. A broad range of applications and services seek to integrate these platforms into non-segregated airspace.

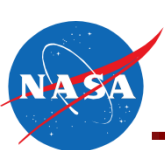
In order to safely integrate these platforms into non-segregated airspace, both a robust Detect and Avoid (DAA) and robust and secure Command and Control (C2) Data Link capability need to be established.

The Federal Aviation Administration (FAA) established the Unmanned Aircraft Systems Integration Office to integrate Unmanned Aircraft Systems (UAS) safely and efficiently into the National Airspace System (NAS).

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RTCA SC-228 ToR





UAS Integration in the NAS Project

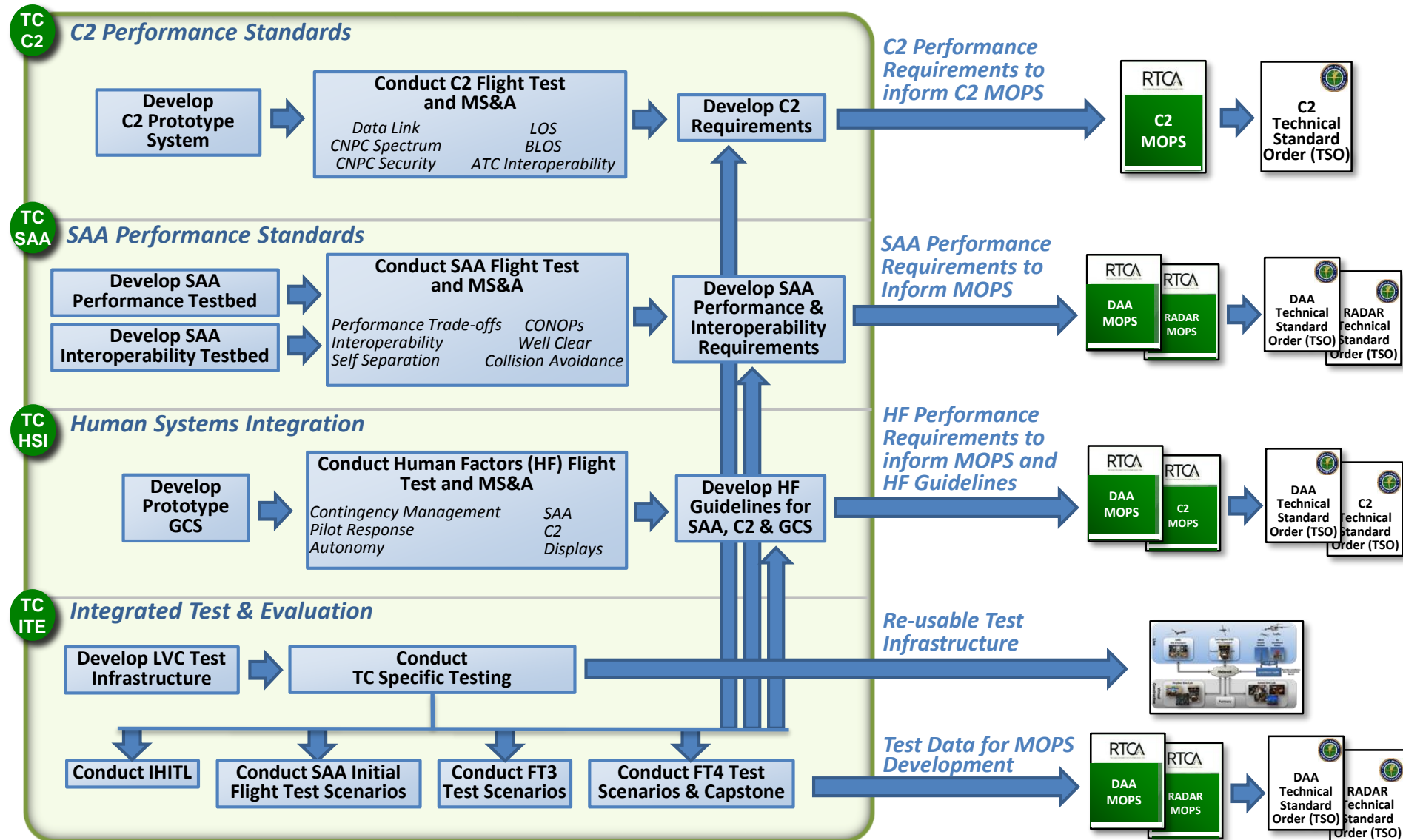
Phase 1 MOPS Value Proposition Flow Diagram

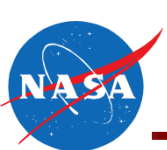


NASA UAS-NAS Project Activities

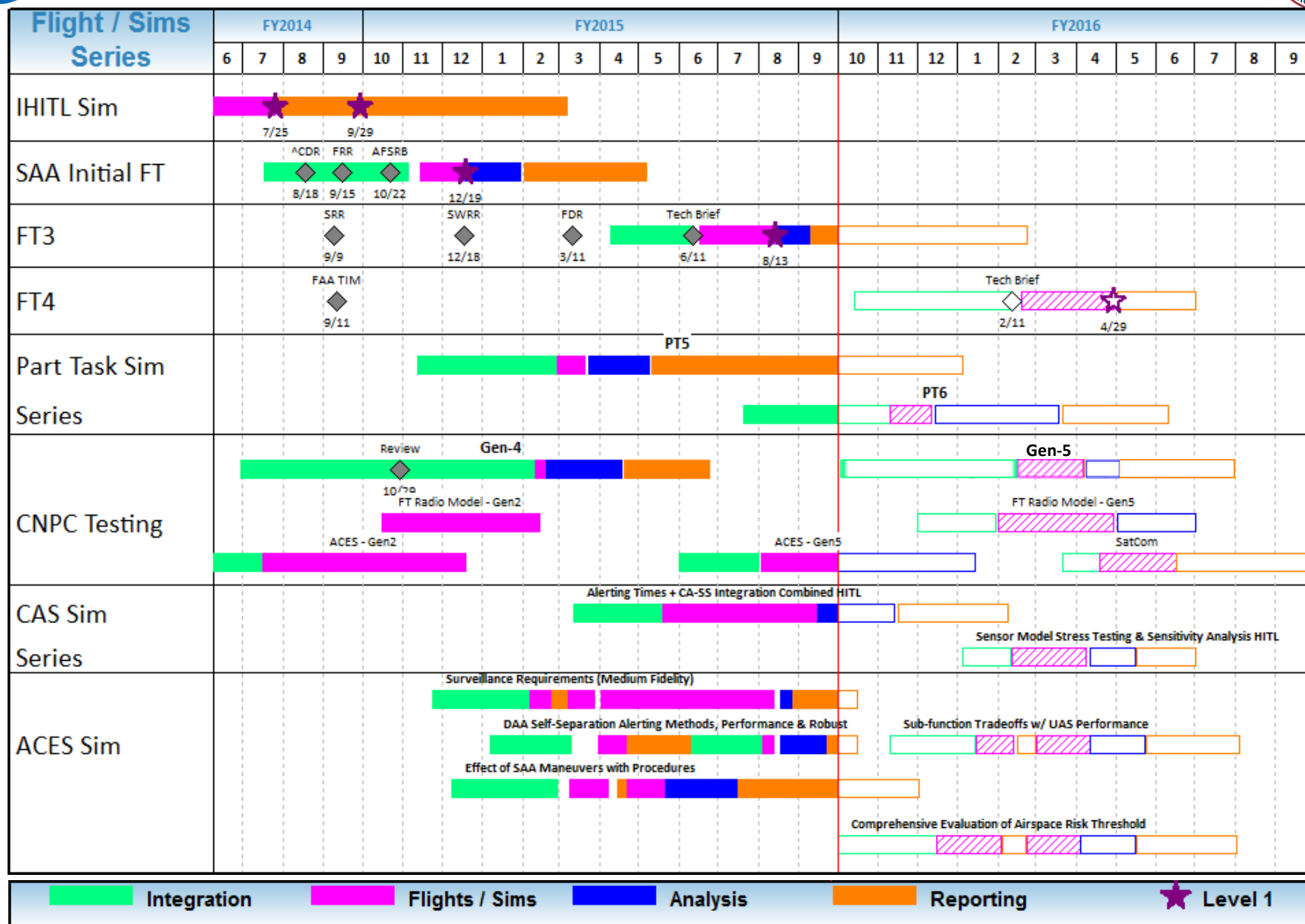
Key Products

Resultant Outcomes

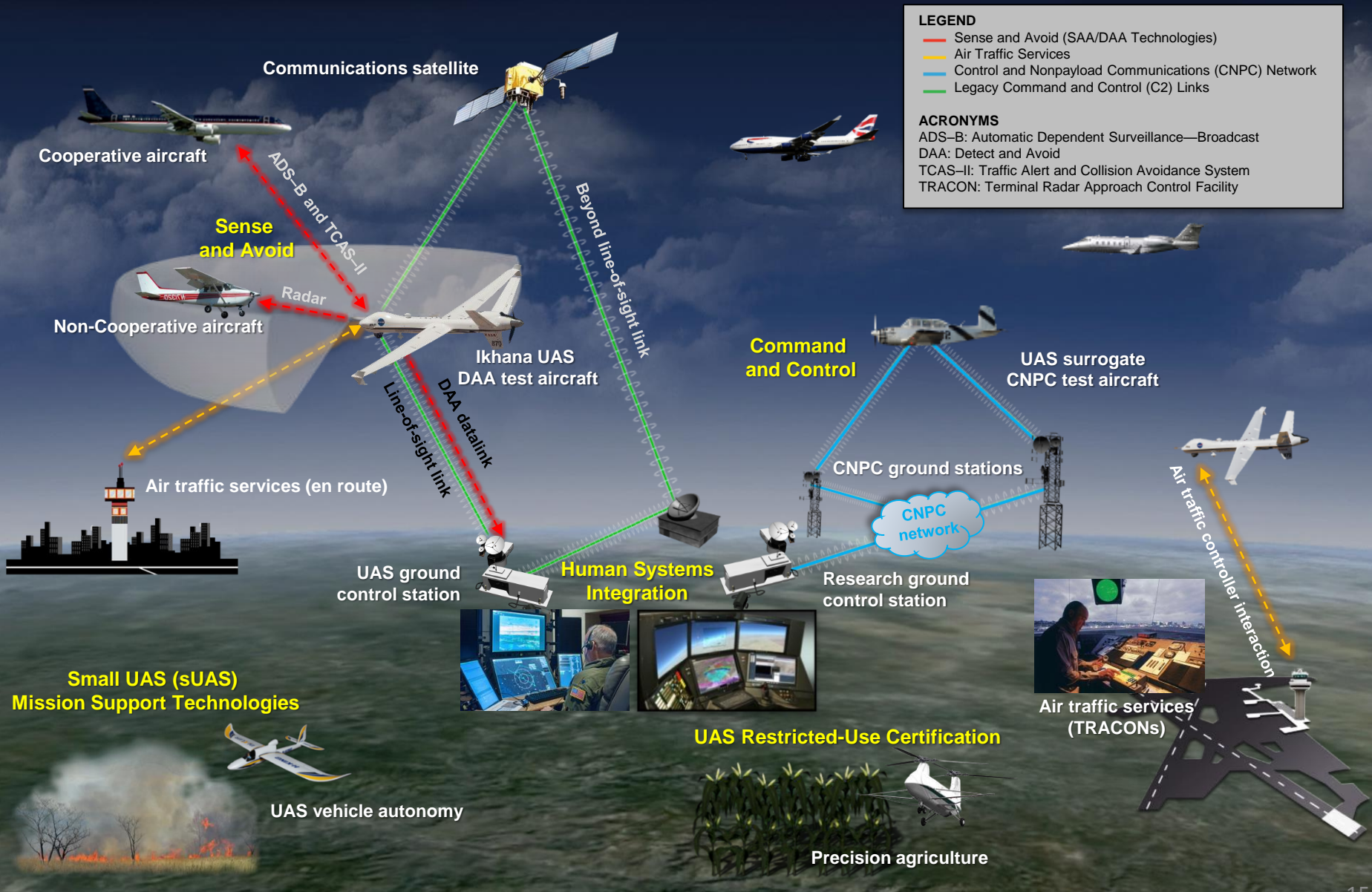


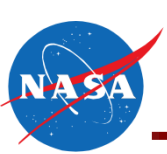


Flight and Simulation Overview



Red Status Line Date: 9/30/15





Outline



- UAS-NAS Overview
- Technical Challenge Performance – Debra Randall
 - TC-C2
 - TC-SAA
 - TC-HSI
 - TC-ITE
- Non-Technical Challenge Work
- Project Processes Implementation
- Project Level Performance & FY16 Look Ahead
- Review Summary



- Technical Challenge progress is tracked by means of Progress Indicators
 - Schedule Package (SP) L2 milestones are the data points for these plots
- Assessed individual contribution towards achieving the overall technical challenge
 - High = 2, i.e. Integrated Tests
 - Moderate = 1, i.e. multiple subproject technologies
 - Low = 0, i.e. foundational activities
- Results normalized and placed on a 10 point maturity scale
- Progress Indicators, i.e. lower portion of the plot, represent execution/data collection of Project SP activities
- Tech Transfer (i.e. upper portion of the plot), plotted to coincide with execution, represents the data analysis and reporting of SP Activities
- Progress is tracked against all the tasks in the schedule package using a red, yellow, green indicator

The diagram illustrates the tracking of technical challenge progress through three interconnected components over time (Fiscal Year 2012 to 2014).

RTCA (Regulatory Technical Change) Timeline:

- Key milestones include *SC-228 Whitepaper* and *Preliminary Ph 1 MOPS*.

Tech Transfer Timeline:

- Key milestones include *ITU-R*, *SARP*, and *SARP*.

Progress Indicators (PI) Graph:

- The Y-axis represents **Maturity** (0 to 10).
- The X-axis represents **Fiscal Year** (2012 to 2014).
- Progress Indicators (PI-1 to PI-8) are plotted as data points, showing their maturity level over time.
- PI-1 through PI-5 are at maturity 0. PI-6 is at maturity 3. PI-7 is at maturity 2. PI-8 is at maturity 6.

Legend:

- ↑ Tech Transfer to RTCA (+ other orgs)
- ↓ Inputs from RTCA
- ◆ Completed
- ◆ In work
- ◆ In work
- ◆ In work
- ◇ Not yet
- ◇ L2 Milestone

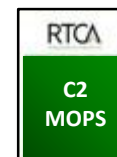


RT1

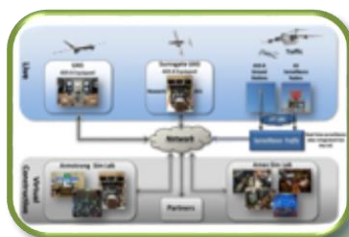
- UAS Integration
 - Airspace integration procedures and performance standards to enable UAS integration in the air transportation system

TC-C2

- Provide research findings to develop and validate UAS Minimum Operational Performance Standards (MOPS) for terrestrial command and control (C2) communication



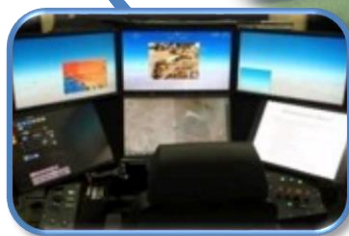
TC-ITE: Integrated Test & Evaluation



TC-C2: Command & Control Performance Standards

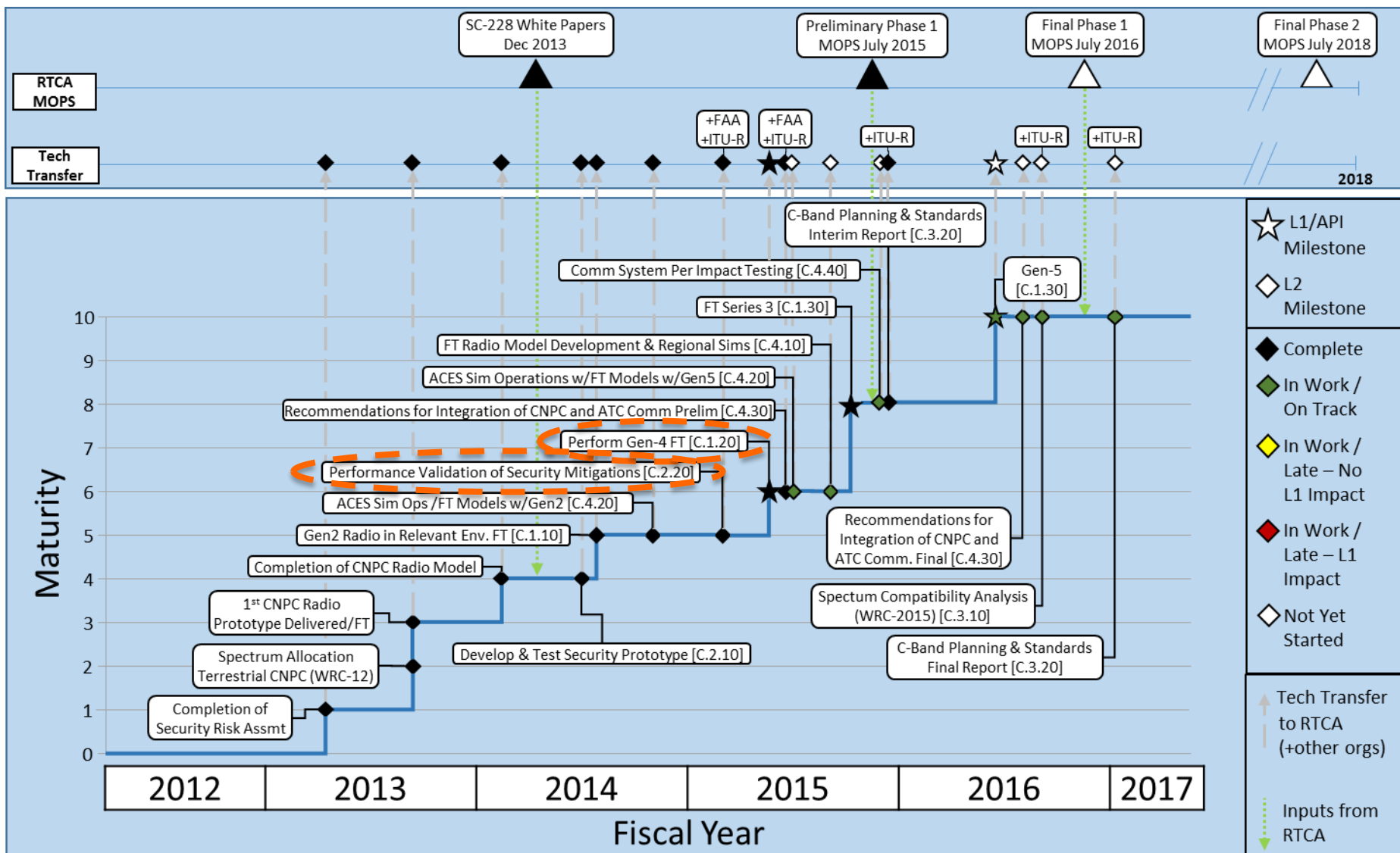


TC-HSI: Human Systems Integration



TC-SAA: Sense and Avoid Performance Standards

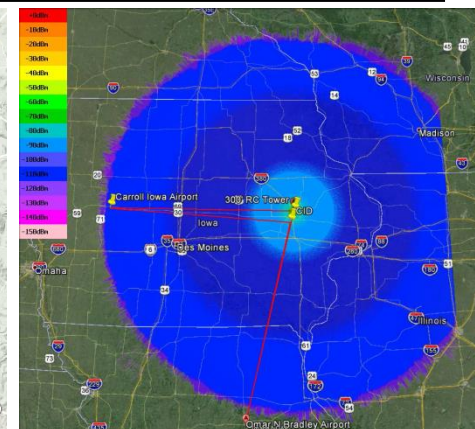
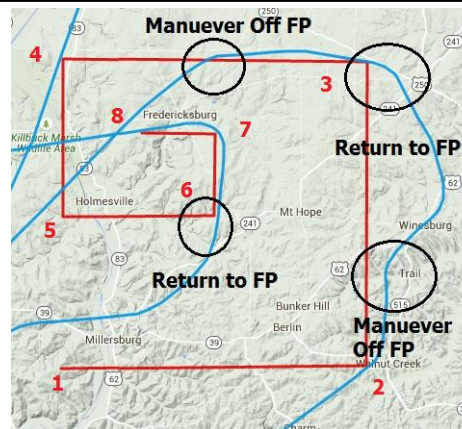
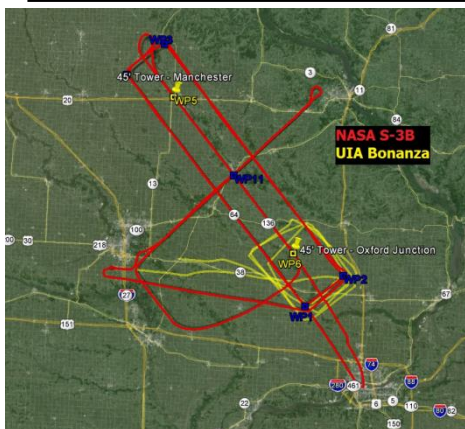




As of 9/30/15

- Research Objective:**

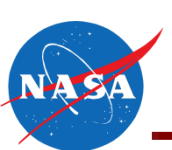
- Analyze the performance of the fourth generation Control and Non-Payload Communication System prototype in a relevant flight environment



- Results, Conclusions, and Recommendations:**

- Demonstrated use of multiple ground stations and multiple aircraft during Gen-3 flight testing at Rockwell Collins in Cedar Rapids, IA
 - Completed development and testing of GRC T-34C surrogate aircraft using Gen-3 CNPC radios
 - Completed flight test of Gen-4 CNPC radios, using Rockwell Collins developed small-form-factor 1W radio hardware
 - Results of Gen-3&4 CNPC radio development and testing were delivered to RTCA SC-228 C2 working group for incorporation into Draft C2 MOPS

CNPC Radio for Development and V&V of C2 MOPS

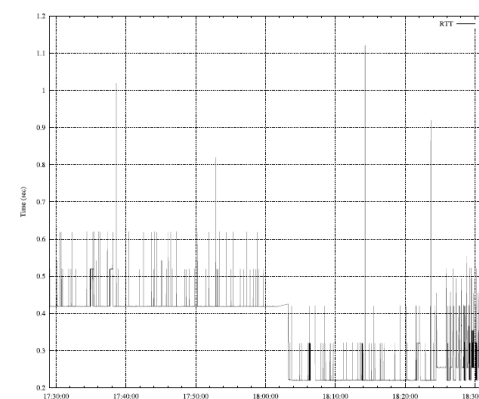
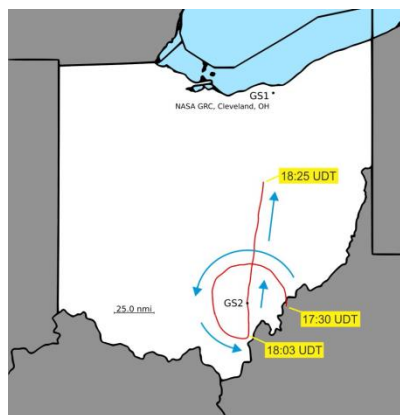
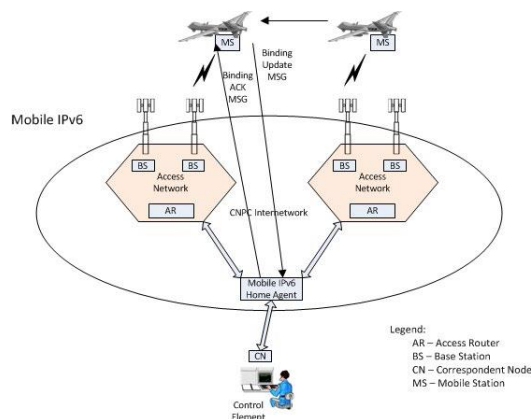


Performance Validation of Security Mitigations - Relevant Flight Environment



- **Research Objective:**

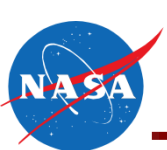
- Determine Control and Non-Payload Communication security recommendations for civil UAS operations based on analysis of flight test results



- **Results, Conclusions, and Recommendations:**

- Completed flight test of CNPC system security controls
 - Demonstrated strong mutual authentication between the end nodes
 - Demonstrated end-to-end confidentiality and integrity protection
 - Demonstrated seamless system functions to the end users and will dynamically create security associations as required to protect network flows
- Flight test report was completed and released
- Security requirements validated in this flight test were incorporated into the C2 Preliminary MOPS

CNPC System Security Requirements for C2 MOPS



TC-C2: C2 MOPS Contributions



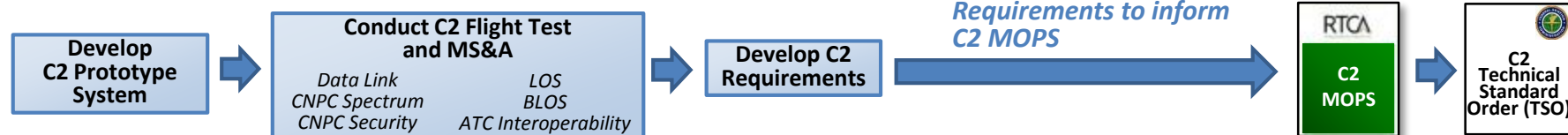
NASA UAS-NAS Project Activities

Key Products

Resultant Outcomes



C2 Performance Standards



- Data and text to Preliminary MOPS sections and appendices
- Designed, developed, and tested (laboratory & flight) a prototype radio
- Provided prototype radio performance from laboratory and flight tests to C2 Working Group for Preliminary MOPS development
- Developed a NAS-wide CNPC system simulation validated with flight test data
- Technical report for ITU-R Working Party 5B to support Fixed Satellite Service (FSS, i.e. commercial satellite services) BLOS CNPC capability decisions

RT1

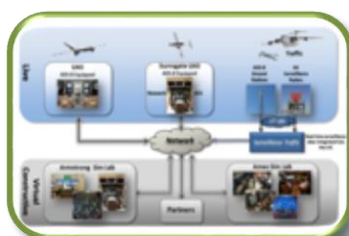
- UAS Integration

- Airspace integration procedures and performance standards to enable UAS integration in the air transportation system

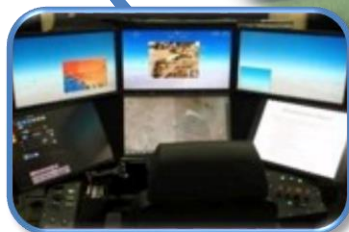
TC-SAA

- Provide research findings to develop and validate UAS Minimum Operational Performance Standards (MOPS) for sense and avoid (SAA) performance and interoperability

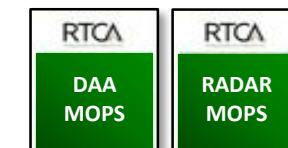
TC-ITE: Integrated Test & Evaluation



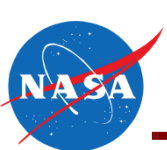
*TC-C2:
Command & Control
Performance
Standards*



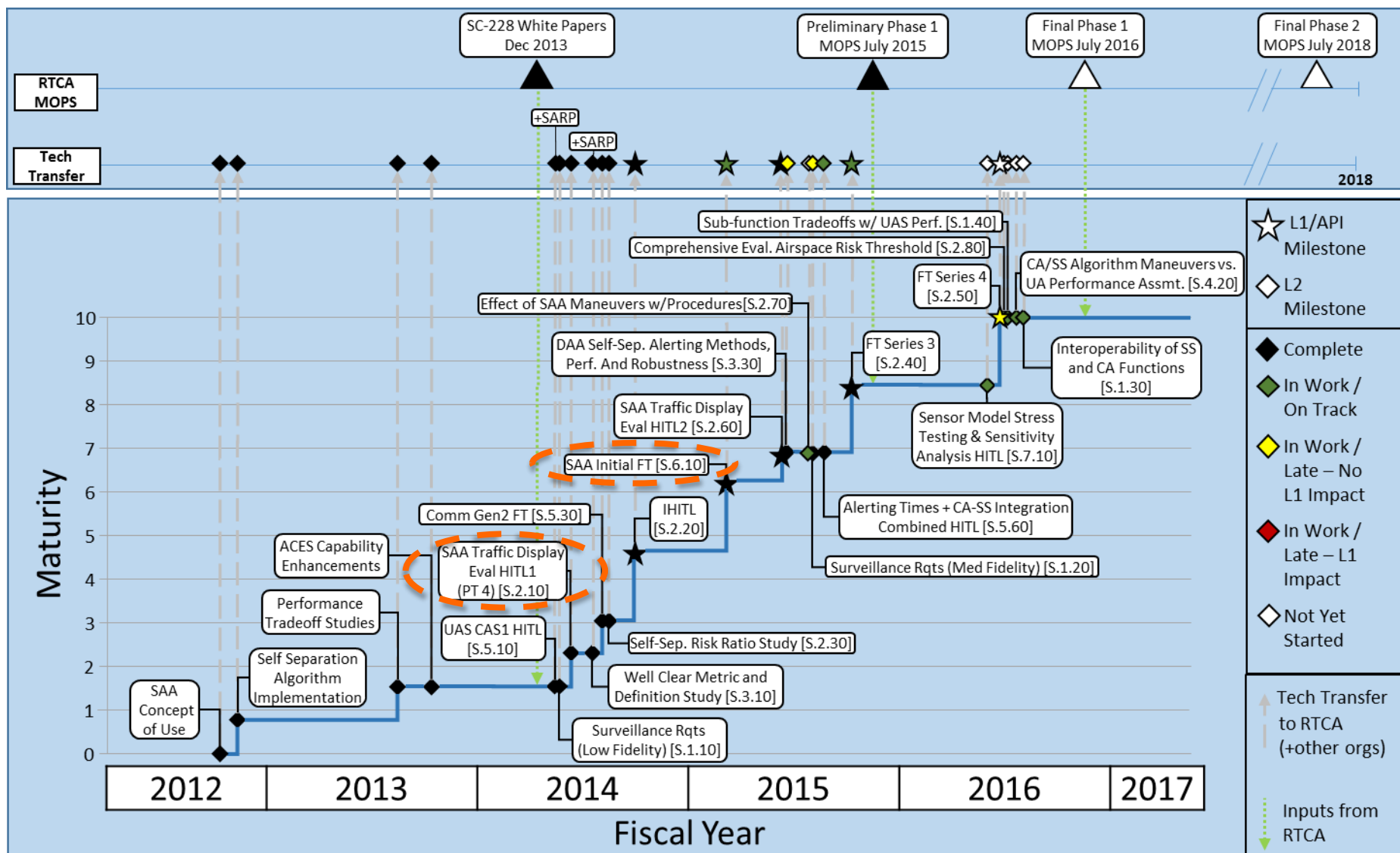
*TC-HSI: Human
Systems Integration*



*TC-SAA:
Sense and Avoid
Performance
Standards*

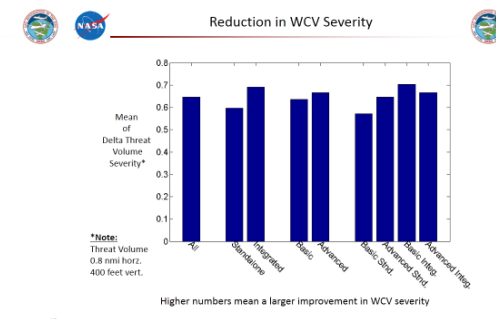


TC-SAA: Progress Indicator



As of 9/30/15

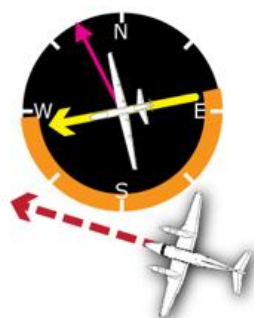
- Evaluate integrated SAA system under perfect sensor conditions
- Evaluate the pilot's ability to remain clear as a function of self separation threshold
- Evaluate the pilot's acceptability of recommended Autoresolver maneuvers to avoid loss of Well Clear
- Evaluate the utility of two different trial planner capabilities that aid an UAS in remaining Well Clear of other traffic



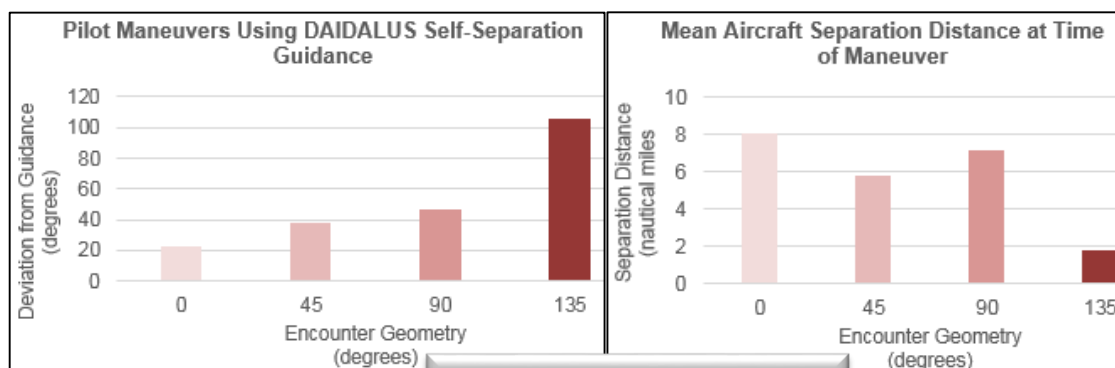
- No significant difference in remaining Well Clear given self-separation alerts at 80 vs. 110 seconds
- Pilots were almost never able to remain Well Clear when first alerted at 55 seconds to CPA or less
- Incorporation of ‘Advanced’ DAA information and tools significantly reduced the proportion of Loss of Well Clear when compared to the ‘Basic’ configuration
- Integration of DAA traffic information and tools with the pilot’s ground control station did not significantly improve the pilots ability to remain well clear
 - Other human systems integration research reveals difference in response time and workload

- Research Objective:**

- Perform collaborative flight tests and demonstrations to evaluate, validate and refine simulation-tested SAA concepts in an actual flight environment with prototype airborne sensors, prototype C2 radio links, and prototype ground station information displays



Display Guidance

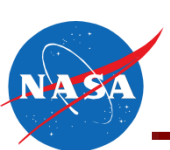


Results

- Interim Results, Conclusions, and Recommendations:**

- Self-separation guidance from Stratway+ was effective, stable, understandable, and usable
 - Matured data collection capability
 - Applied lessons learned to Flight Test Series 3 and Collision Avoidance Self-separation Alerting Times human-in-the-loop simulation

DAA System Maturation for Development and V&V of DAA MOPS



TC-SAA: DAA and Air-to-Air RADAR MOPS Contributions



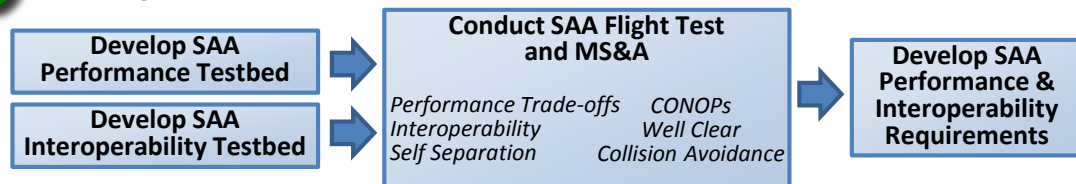
NASA UAS-NAS Project Activities

Key Products

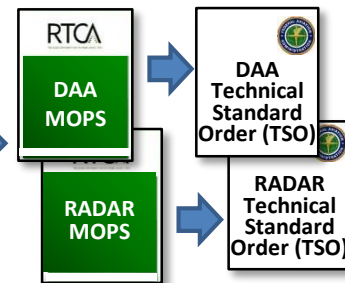
Resultant Outcomes



SAA Performance Standards



SAA Performance Requirements to inform DAA and RADAR MOPS



- Data and text to Preliminary MOPS sections and appendices
- Further assessment of Well Clear definition
- Further development of maneuver guidance algorithms
- Data collection contributing to DAA alerting requirements and performance
- Assessment of airborne radar intruder frequency and detection range sensitivity on Preliminary MOPS alerting requirements
- Analysis of surveillance errors and other representative uncertainties in flight test and calibration of simulation models
- Provide sample DAA algorithm

RT1

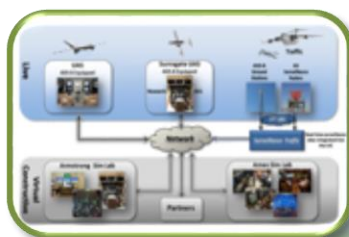
- UAS Integration

- Airspace integration procedures and performance standards to enable UAS integration in the air transportation system

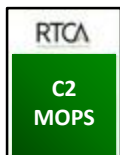
TC-HSI

- Provide research findings to develop and validate human systems integration (HSI) ground control station (GCS) guidelines enabling implementation of the SAA and C2 performance standards

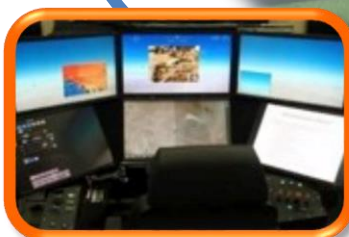
TC-ITE: Integrated Test & Evaluation



TC-C2: Command & Control Performance Standards

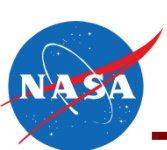


TC-HSI: Human Systems Integration

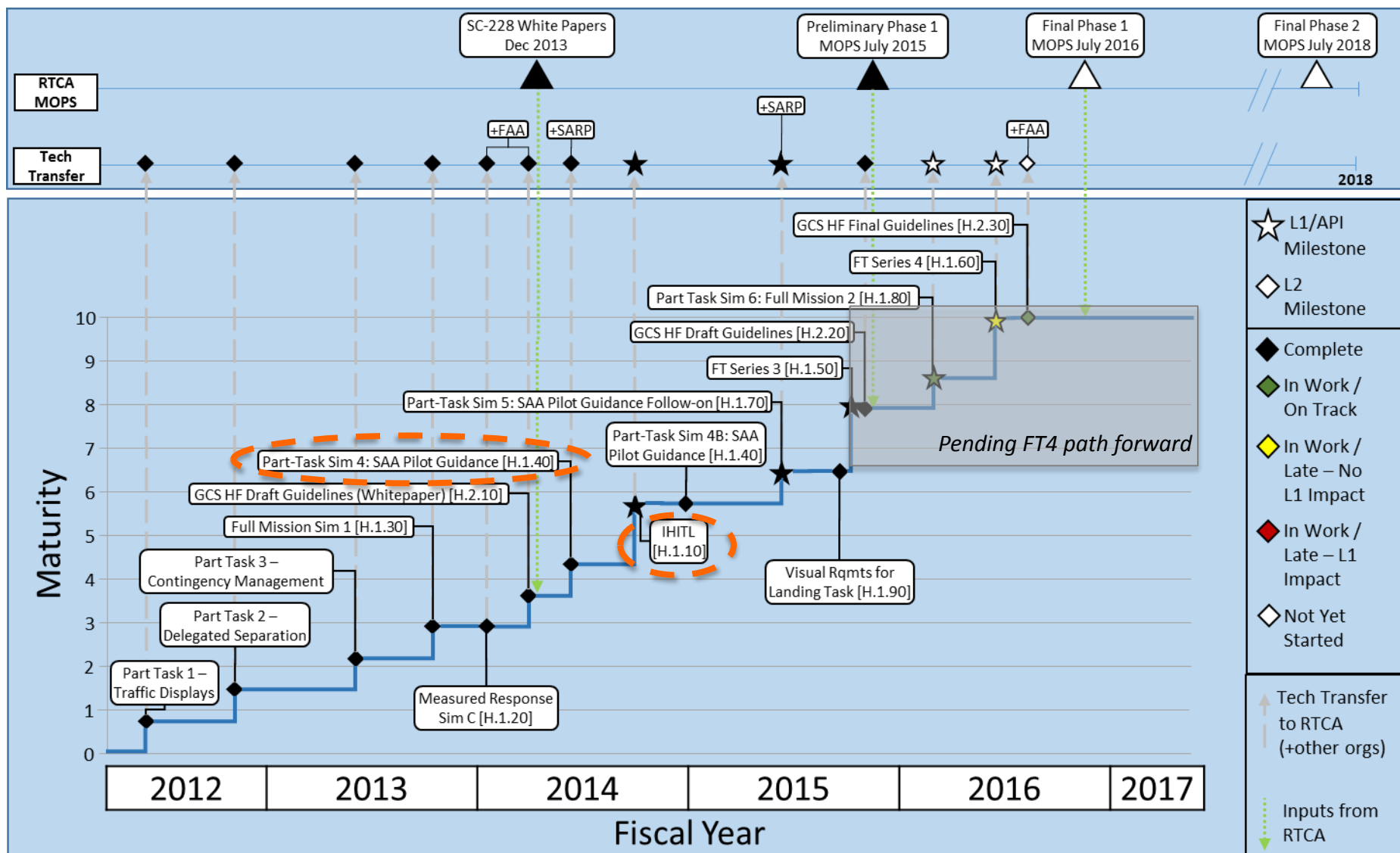


TC-SAA: Sense and Avoid Performance Standards





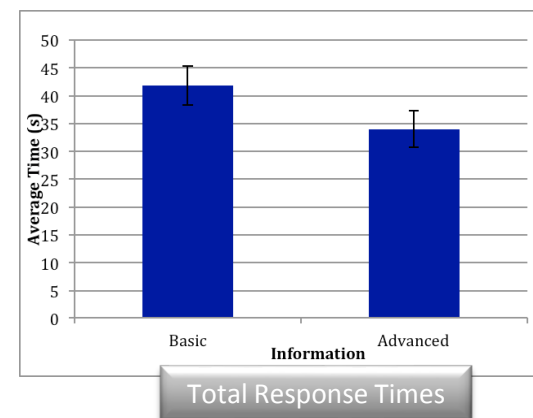
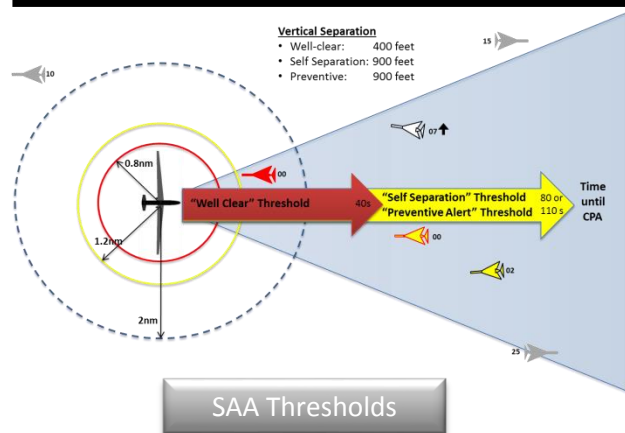
TC-HSI: Progress Indicator



As of 9/30/15

Research Objective:

- Evaluate efficacy of minimum information SAA displays, potential improvements for advanced information features and pilot guidance, and integrated vs stand-alone GCS SAA displays

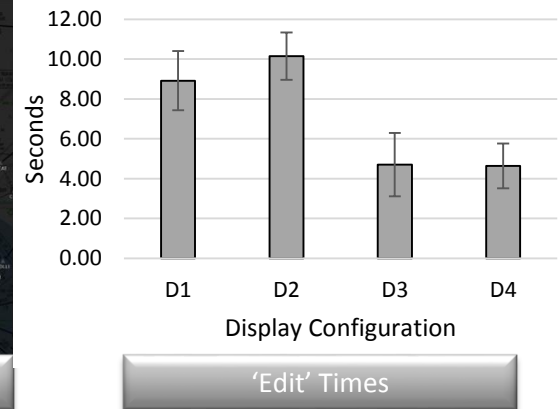


Results, Conclusions, and Recommendations:

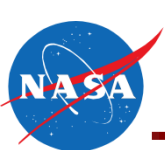
- Consistent advantage seen for Advanced over Basic displays
 - Faster Total Response Times compared to Basic
- No significant differences between the Standalone and Integrated condition
- Fern, L., Rorie, R. C., Pack, J., Shively, J., & Draper, M. (2015). An evaluation of detect and avoid (DAA) displays for unmanned aircraft systems: The effect of information level and display location on pilot performance. In *15th AIAA Aviation Technology, Integration, and Operations Conference* (p. 3327)

GCS Display Minimum Information Guidelines/Requirements for DAA and C2 MOPS

- **Research Objective:**
 - Evaluate an instantiation of the prototype GCS in relevant environment



- **Interim Results, Conclusions, and Recommendations:**
 - Integration of guidance and auto pilot in the *auto-resolver* and *auto resolver + vector planner* conditions led to significantly faster pilot 'edits'
 - No other significant differences in pilot response times
 - Rorie, R. C., & Fern, L. (2015). The impact of integrated maneuver guidance information on UAS pilots performing the detect and avoid task. *Proceedings of Human Factors and Ergonomics Society*, Los Angeles, CA, Oct 26-30



TC-HSI: DAA and C2 MOPS Contributions



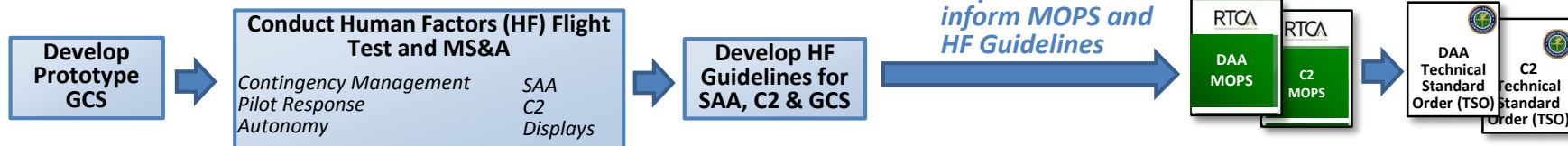
NASA UAS-NAS Project Activities

Key Products

Resultant Outcomes



Human Systems Integration



- Data and text to Preliminary MOPS sections

DAA MOPS

- Further development of alerting timeline and GCS display
- Further development of maneuver guidance display
- Evaluation of the effects of sensor uncertainty
- Development assessment of TCAS/DAA interoperability

C2 MOPS

- Defined C2-related GCS information requirements enabling pilot management and monitoring of the C2 Link
- Examined video considerations for UAS C2 in civil airspace

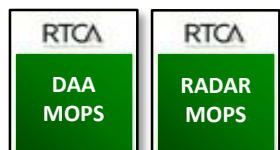
RT2

– Test Infrastructure

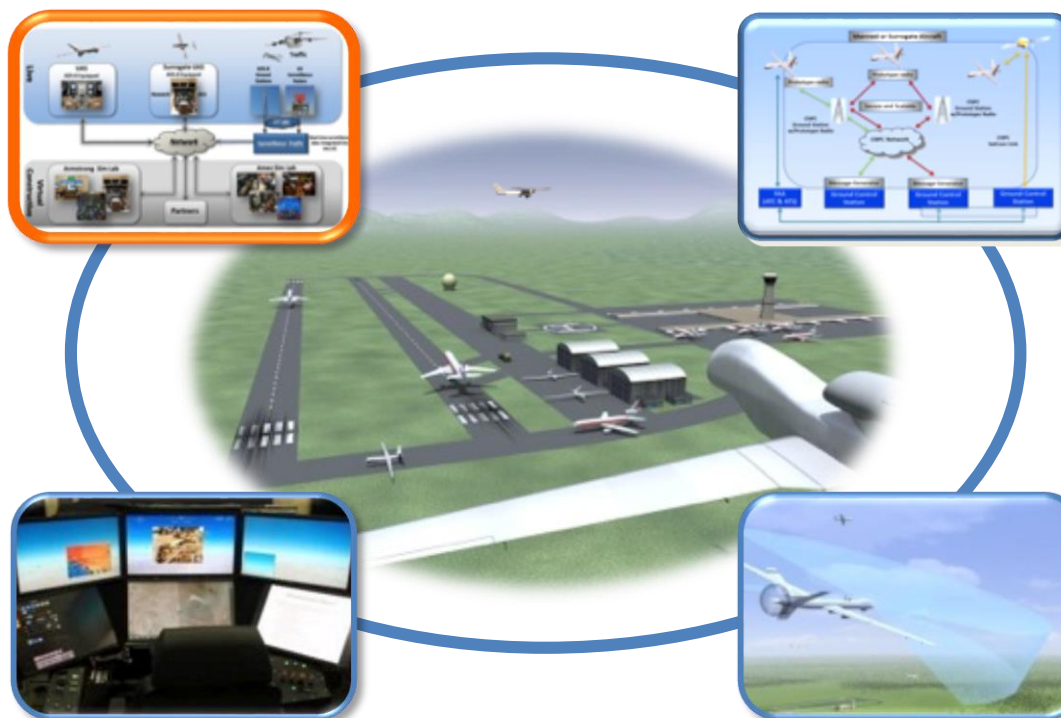
- Test infrastructure to enable development and validation of airspace integration procedures and performance standards

TC-ITE

- Develop a relevant test environment for use in generating research findings to develop and validate HSI Guidelines, SAA and C2 MOPS with test scenarios supporting integration of UAS into the NAS



TC-ITE: Integrated Test & Evaluation

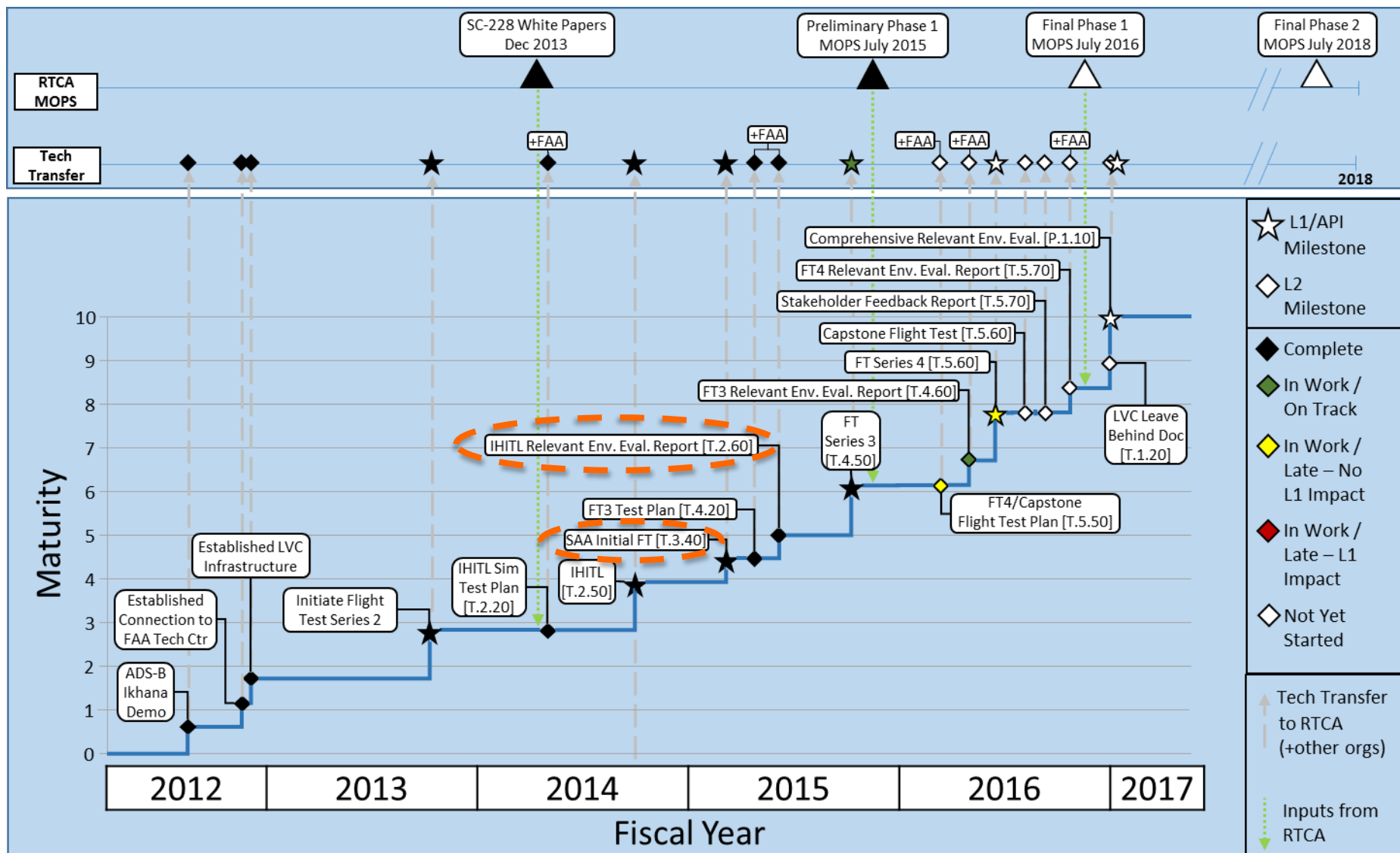


**TC-C2:
Command & Control
Performance
Standards**

**TC-SAA:
Sense and Avoid
Performance
Standards**

**TC-HSI: Human
Systems Integration**

TC-ITE: Progress Indicator



As of 9/30/15

- **Objective:**
 - Report on the Integrated Human-in-the-Loop Relevant Environment Analysis



IHITL Virtual Airspace



IHITL UAS RGCS and Display



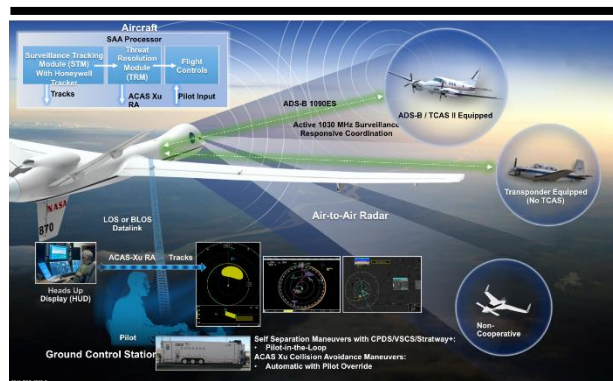
IHITL Well Clear Simulator

- **Results, Conclusions, and Recommendations:**
 - IHITL successfully utilized the LVC connections to distribute simulation activities between ARC/AFRC and ARC/LaRC
 - Emulation of actual Oakland and Dallas Ft. Worth airspaces
 - DAA algorithms performance evaluated with UAS pilots and ATC controllers
 - Latencies measured among distributed participating assets
 - UAS Pilot and ATC controller subjects provided feedback on the test environment and traffic scenario realism

Test Environment for V&V of DAA and C2 MOPS

Research Objectives:

- Conduct SAA Initial Flight Test using the Live, Virtual, Constructive test environment
- Document the performance of the test infrastructure in meeting the flight test requirements



Flight Test Architecture



Autoresolver Self-Separation Display



Stratway+ Self-Separation Display

Results, Conclusions, and Recommendations:

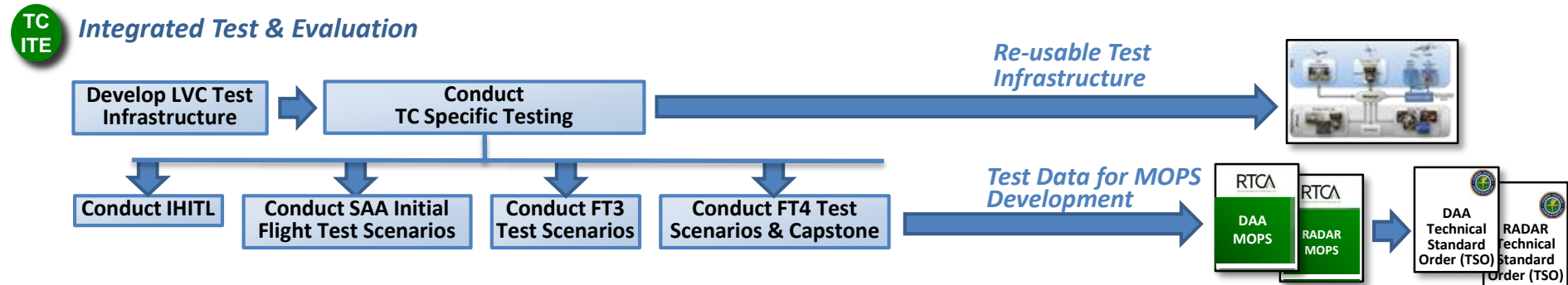
- Flight tests conducted in December 2014
- 3 unmanned vs. manned flights and 55 encounters completed
- Successful risk reduction activities completed to include SAA algorithm refinements, sensor noise modeling, sensor noise filtering, data collection and dissemination efficiencies, and flight test operations

Test Environment for V&V of DAA and C2 MOPS

NASA UAS-NAS Project Activities

Key Products

Resultant Outcomes



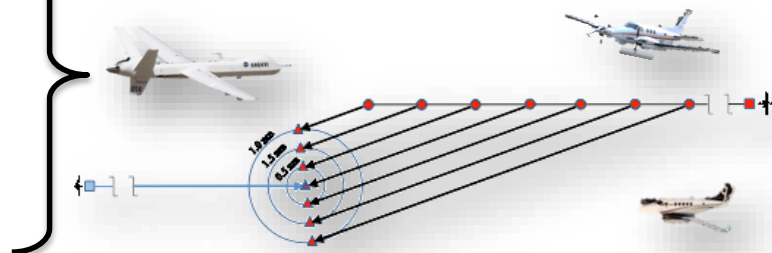
- Data provided to PEs and Partners for DAA and Radar MOPS development
- Further development of live, virtual, constructive distributed test environment
- Designed and developed a data archive scheme for integrated events
- IHITL Relevant Environment Analysis
- Completion of PT5
- Completion of SAA Initial Flight Test Execution
- Completion of FT3 Execution

Top Level Research Goals:

- Validate results previously collected during project simulation testing with live data
 - Sensor performance, uncertainty
 - State data uncertainty
 - Wind compensation
 - Inform final DAA MOPS
- Test fully integrated system in a relevant live test environment
 - HSI Proof of Concept GCS and pilot guidance displays
 - CNPC performance
 - Inform final DAA and C2 MOPS
- Reduce risk for Flight Test Series 4
 - More complex multi-vehicle scenarios

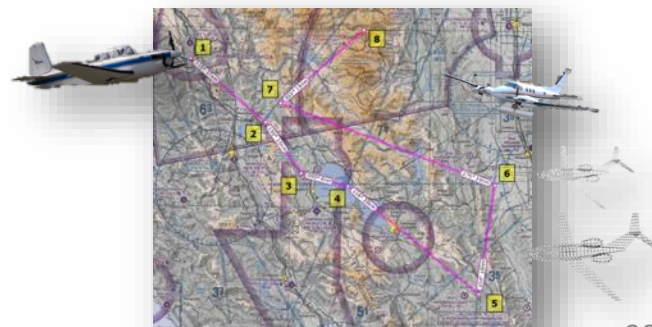
Configuration 1 - Scripted Encounters

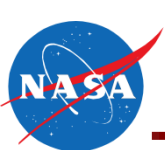
- Live Ownship with Cooperative and Non-Cooperative Sensors
- Live Intruder(s)



Configuration 2 - Full Mission Evaluations

- Live Ownship (Surrogate UA)
- Live and Virtual Intruders
- Representative Operational Mission
- UAS Pilot Participants



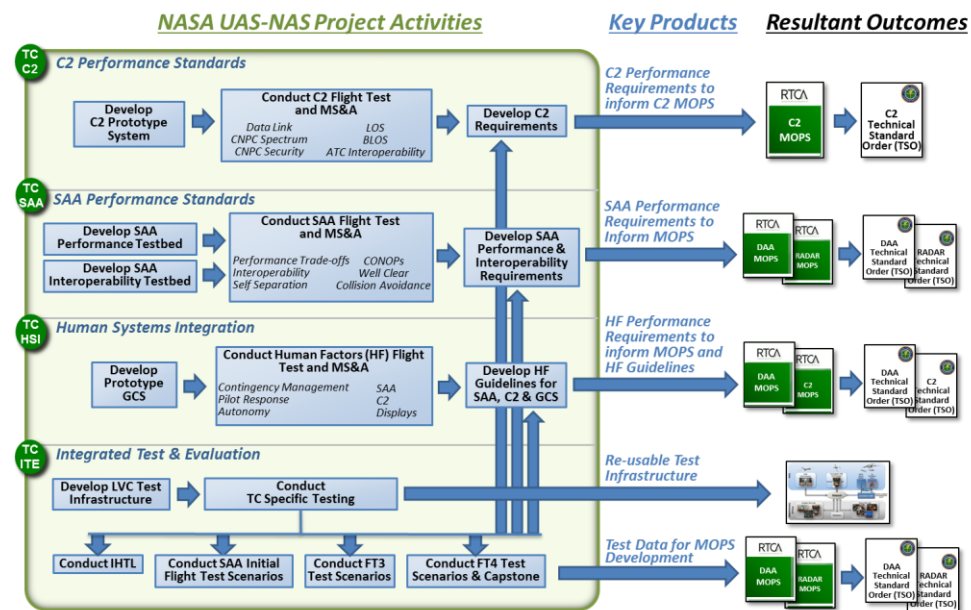


FT3 Lessons Learned and FT4 Path Forward

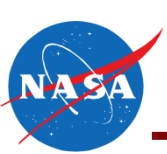


- Lessons Learned
 - Multiple integration deficiencies
 - Surrogate UA: Improper RGCS display of information; intermittent INS data dropouts; latency of aircraft response to pilot command (unrelated to CNPC performance; due to surrogate implementation)
 - LVC/RGCS: MACS display clutter and fidelity
 - Multiple causes
 - Requirement definition
 - Multi-Center end-to-end test planning
 - Shakedown, integration, and combined system checkout schedule and success criteria
 - Communication and Technical discussions
- FT4 Path Forward
 - Post-FT3/FT4 Path Forward Meetings
 - #1 (8/24-25/2015): Technical and non-technical issue identification and discussion; Short-term actions identified and assigned
 - #2 (9/9-10/2015): Identified (single) FT4 Lead; first set of full mission ownership options
 - Decision Gate 1 (10/8/2015)
 - Triage full mission ownership options based on technical, development, or partnering/contracting risk
 - Decision Gate 2 (11/13/2016)
 - Select the best option (technical, cost, and schedule)
 - Identify actions for or approve changes to research portfolio

- World Radio Conference
 - Fixed Satellite Service BLOS CNPC capability analysis
- NATO and ICAO
 - Human Autonomy Teaming support
 - Provide HF leadership and expertise
- Preliminary MOPS
 - Expertise influencing deliberations
 - Timely and valuable research findings from simulation, flight test, and integrated flight test
 - Narrative text to multiple sections and appendices
- Future Research Portfolio shaping
 - Continuous involvement with SC-228 and FAA



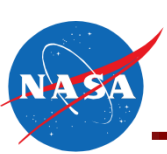
Poised to provide timely, valuable input to Final MOPS and international community



Outline



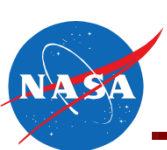
- UAS-NAS Overview
- Technical Challenge Performance
- Non-Technical Challenge Work – Davis Hackenberg
 - FY15 Non-TC Performance
 - Certification
 - sUAS
 - Augmentation
 - FY16 Look Ahead
 - Capstone
 - Future Project Planning
- Project Processes Implementation
- Project Level Performance & FY16 Look Ahead
- Review Summary



Non-Technical Challenge Work



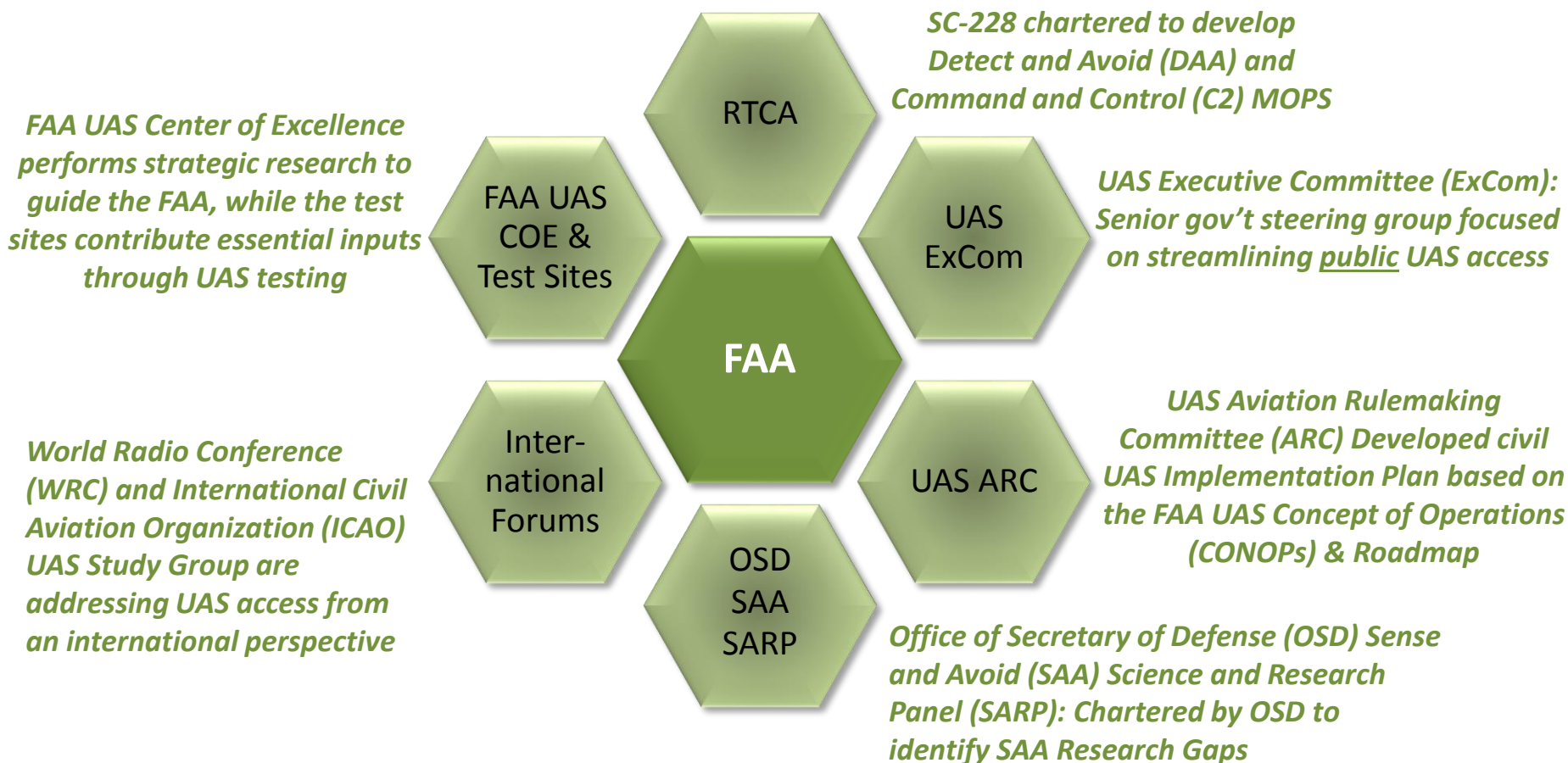
- Non-Technical challenge work is technical work outside the core project focus areas
 - Includes far-reaching/higher risk activities with an emphasis on future (post-project) capabilities
 - Utilizes project management rigor, but to a lesser extent (i.e. No Progress Indicators)
 - Content is not required for min-success of the project
 - Does not have L1 milestones
- Source for resources should TC work encounter unknown risks requiring additional resources for mitigation
- Long term activities have pre-defined off-ramps/on-ramps to facilitate potential TC work needs
 - Off-ramps: Clearly defined breakpoints/stopping places within scheduled activities
 - On-Ramps: New proposed activities that are aligned with the intent of Non-TC work
- Non-TC Work on UAS-NAS Project
 - Certification
 - sUAS
- Activities with on-ramp implications (being book kept as Non-TC work)
 - Augmentation used for LVC-DE Enhancements
 - Capstone Development and exemption
 - Future Project Planning and Full UAS Integration Analysis



FAA Organizational Relationships



- The FAA is using several domestic forums, in conjunction with several international forums to lay out the pathway for their priorities and investments.



NASA has a leadership role within many domestic forums and participates in the international forums

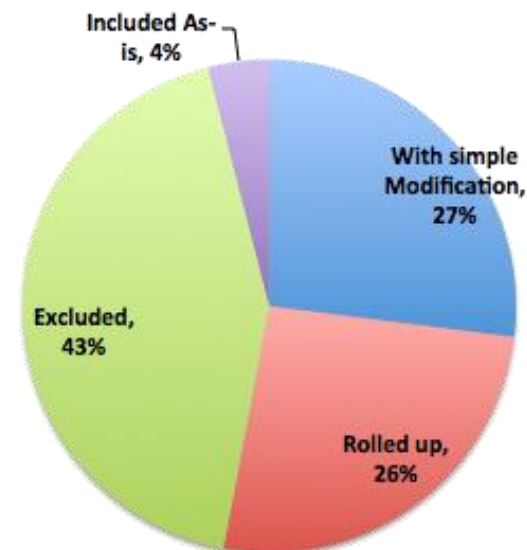
Leveraged operational evaluation approach (agriculture sprayer) and FAA FARs (part 21 & 27) to develop a Mock Type Certification Basis

- A general approach to determining a type certification basis for UAS (leveraging a limited ConOps)
- An example concept of operations document with data needed to support airworthiness certification, and artifacts to help inform the UAS industry about civil certification
- Design and performance criteria derived from hazard analysis and current regulations used to establish
 - Airworthiness requirements for unmanned rotorcraft intended for “low-risk” operations
 - Requirements for new systems and equipment (e.g., a containment system for UAS)
- Recognition that applying current airworthiness standards to UAS is challenging
 - Tailoring will be difficult for many UAS vendors/operators
 - Even for UAS operating in low-risk environments

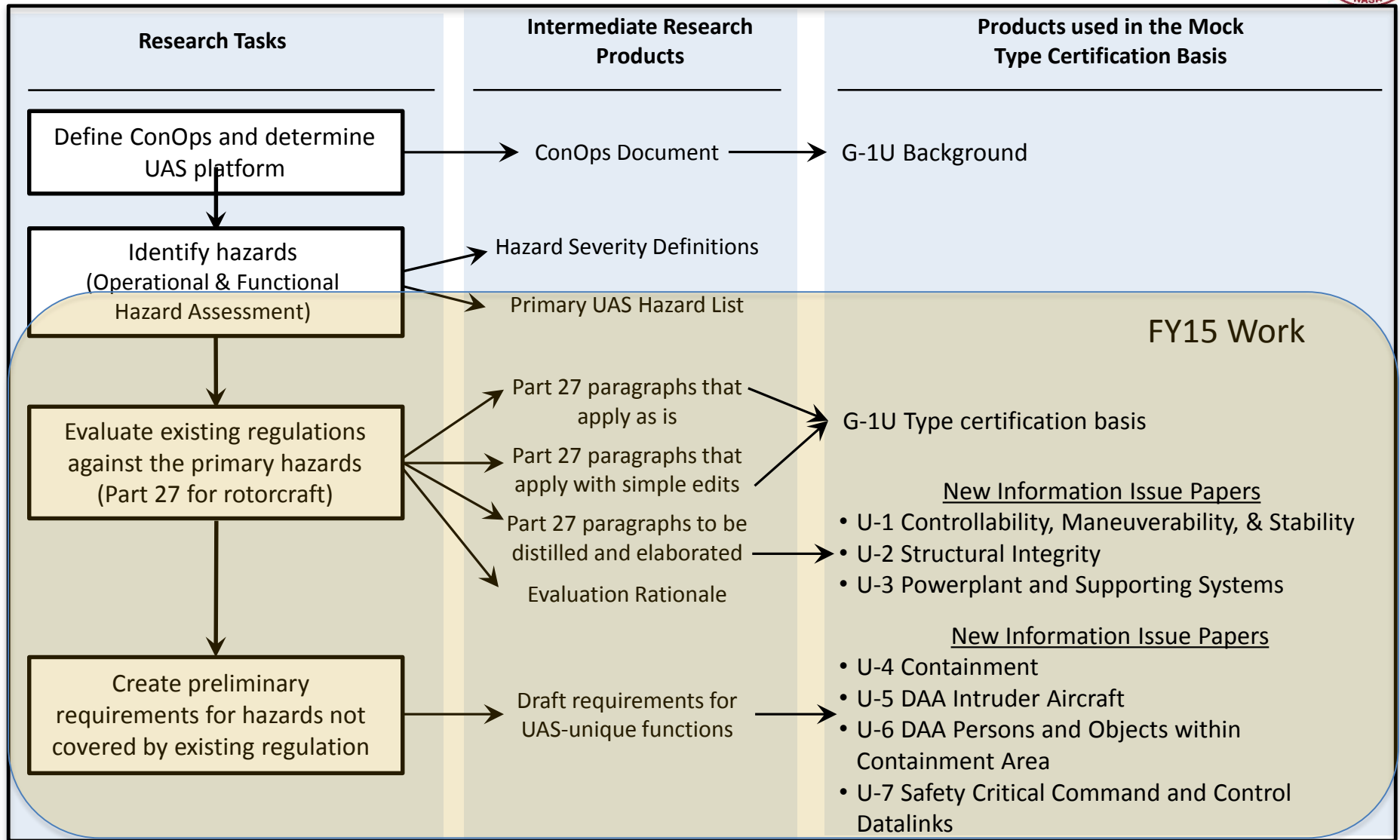


- ❖ Geospatially constrained
- ❖ Farmland (rural area)
- ❖ < 400 ft altitude
- ❖ Line of sight and low visibility conditions

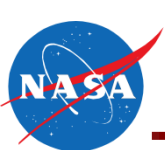
Applicability of Part 27 regulations to an unmanned ag rotorcraft



Hazard-Based Approach



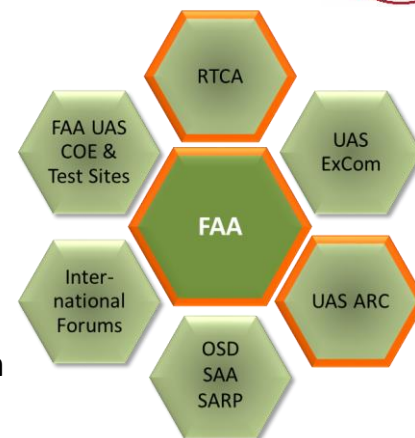
Follow-on work: examine affects of different vehicle characteristics and operational modes certification basis



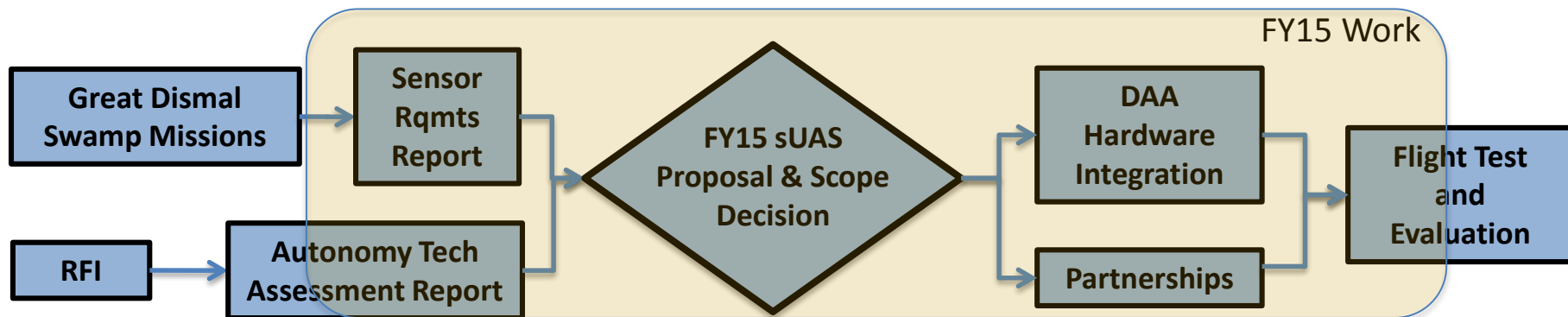
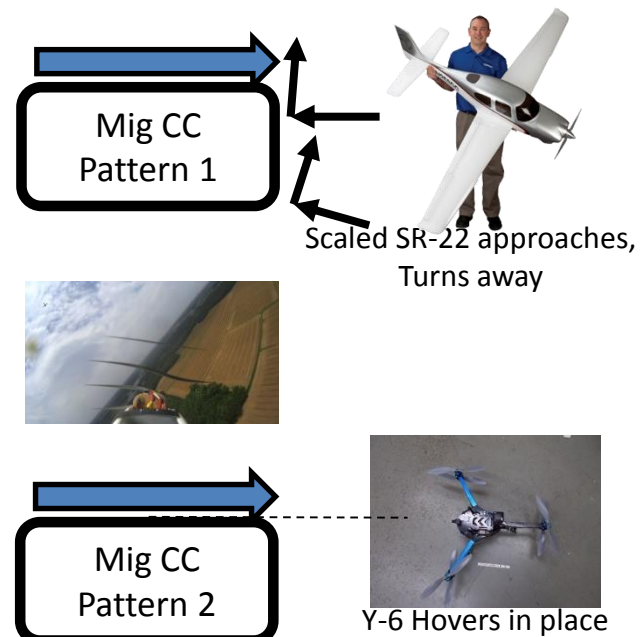
Cert Relationship to FAA Integration Initiatives

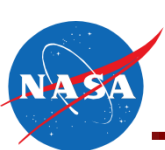


- **FAA Pathfinders**
 - Visual line-of-sight operations in urban areas
 - CNN will look at how UAS might be safely used for news gathering in populated areas.
 - Extended visual line-of-sight operations in rural areas
 - PrecisionHawk will explore how UAS flights outside the pilot's direct vision might allow greater UAS use for crop monitoring in precision agriculture operations.
 - Beyond visual line-of-sight in rural/isolated areas
 - BNSF Railroad will explore command-and-control challenges of using UAS to inspect rail system infrastructure.
- **UAS ARC**
 - “Pathfinders” concept as was part of FAA ARC Implementation Plan
 - “Pathfinders” also relevant to ARC BVLOS Working Group use cases
- **RTCA SC-288**
 - Use case, CONOPS, and vehicle size relevant to P2 MOPS



- **Top Level Research Goal**
 - Developing specific data relevant to partner Agencies while conducting high-value sUAS missions utilizing increasing levels of automation and sUAS technologies
- **Objectives**
 - Assess the state-of-the-art in sUAS Sense-and-Avoid capabilities
 - Develop and test one instantiation of an sUAS SAA system
 - Assess feasibility of BVLOS operation at GDS in Class G airspace
- **FY15 Accomplishments**
 - A series of test conducted to obtain video and telemetry data for various encounters of sUAS platforms
 - Flight tests leveraged an Electro-Optic (EO) cameras
 - 11 single UAS buildup flights, and 12 multi-UAS encounter flights
 - Diverse weather conditions
 - Initial indications seem to show we were getting good data, with internal and partner analysis happening in the coming weeks

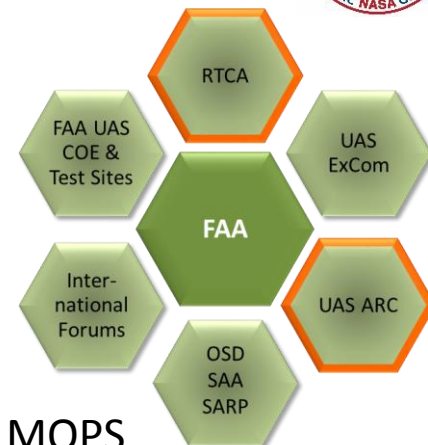


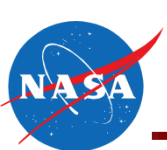


sUAS Relationship to FAA Integration Initiatives



- UAS ARC
 - DAA necessary for many (if not all) ARC BVLOS use cases
- RTCA
 - Use case, CONOPS, and vehicle size may be relevant to Phase 2 MOPS
 - If technology development is successful, RTCA and NASA will have
 - Sensor characterization of a P2 MOPS relevant sensor
 - System capable of representing requirements that would relate to the expected SC-228 P2 TOR



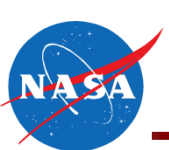


UAS-NAS FY15 Augmentation Details

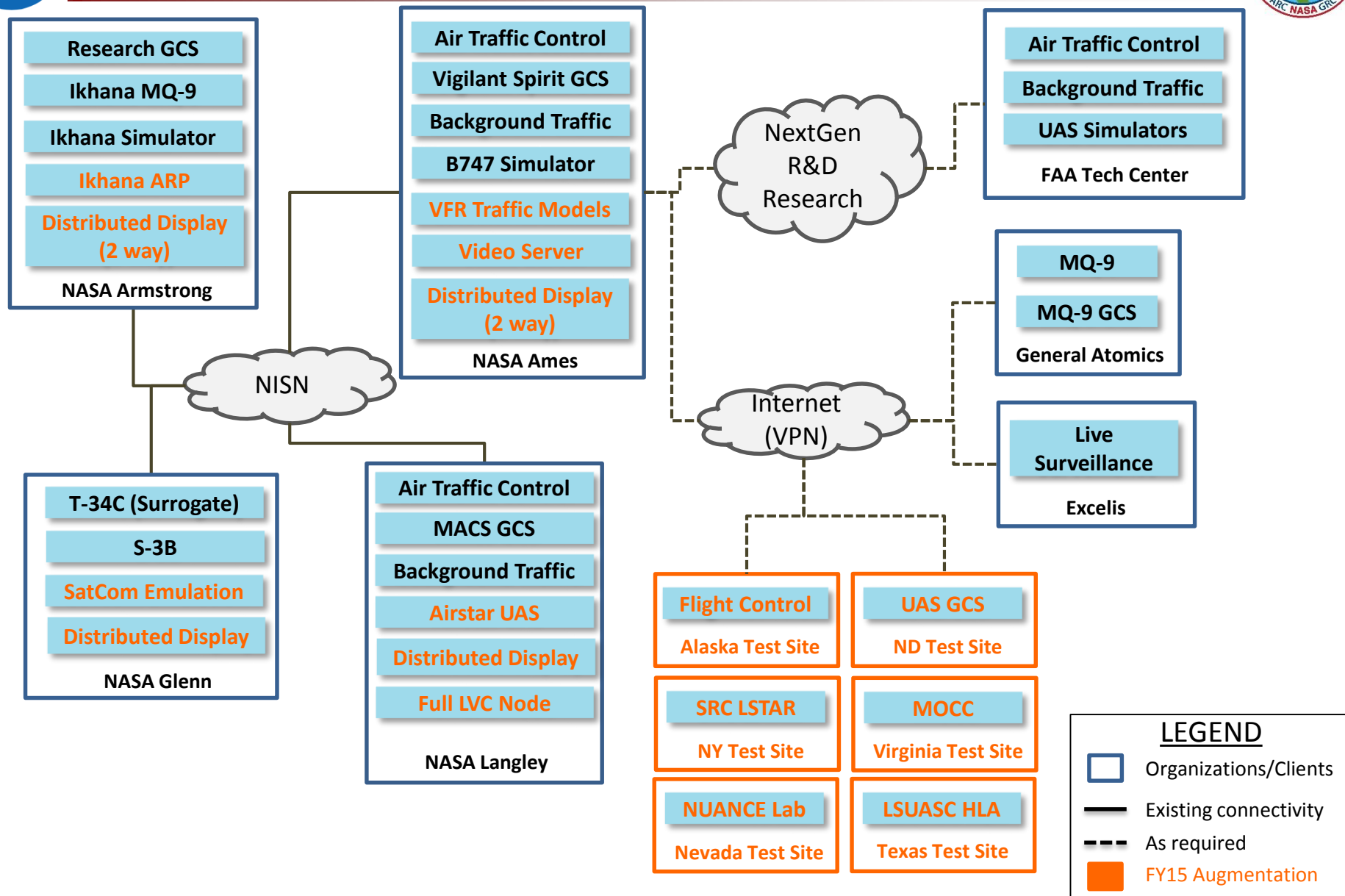


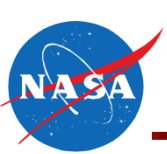
- Purpose
 - LVC Enhancements that would benefit the development of Phase 2 MOPS
- Overview
 - The Project began planning for an Augmentation (congressional add) as early as December 2014
 - Project developed multiple review packages to coordination scope of tasks across ARMD and multiple projects
 - Augmentation tasks have all been successful thus far
 - Financial summary: 99.99% Obligated, 43% Cost
- Augmentation task 3.3 completed, all other tasks are still in work
- Prototype connections to Test Sites was more expensive than anticipated due to late changes to the LVC Prototype Connection task, and the desire to fund all 6 Test Sites

Tasks
<i>3.1 Prototype connection equipment & test site connections</i>
<i>3.2 LVC connection to scaled vehicles</i>
<i>3.3 Investigation of ideal middleware</i>
<i>4.1 VFR Traffic Model Development and Integration</i>
<i>6.1 Distributed Display Infrastructure Set-up</i>
<i>7.1 SatCom emulation capability on LVC</i>
<i>7.2 Adaptable SAA Architecture and LVC Connection</i>



UAS-NAS LVC-DE Build (including Augmentation Tasks)





Outline



- UAS-NAS Overview
- Technical Challenge Performance
- **Non-Technical Challenge Work – Davis Hackenberg**
 - FY15 Non-TC Performance
 - Certification
 - sUAS
 - Augmentation
 - FY16 Look Ahead
 - Capstone
 - Future Project Planning
- Project Processes Implementation
- Project Level Performance & FY16 Look Ahead
- Review Summary

- Capstone is a mission-oriented demonstration subproject technologies, concepts, and procedures (rather than experimentally designed test series)
- The flight demonstrations will showcase the technologies developed by the Project, specifically related to RTCA Phase 1 MOPS
- A demonstration leveraging simultaneous flight of DAA and C2 systems utilizing the LVC-DE will be performed
 - DAA demonstration on Ikhana will include designed encounters integrated into a mission-oriented demonstration in R-2515 and will occur following FT4
 - C2 Terrestrial technologies will be demonstrated on the S-3B after Gen-5 radio Flight Tests
 - LVC will be leveraged to receive data from the Ikhana aircraft, provide that data to the algorithms and displays, provide a distributed video streaming capability, and “co-locate” Ikhana and S-3B
 - All four Centers and Technical Challenges will participate
- Capstone is being coordinated with FT4 planning activity; date of execution will be chosen with consideration for all project related activities

DAA



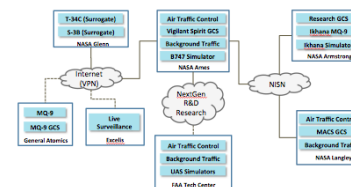
Ikhana

C2

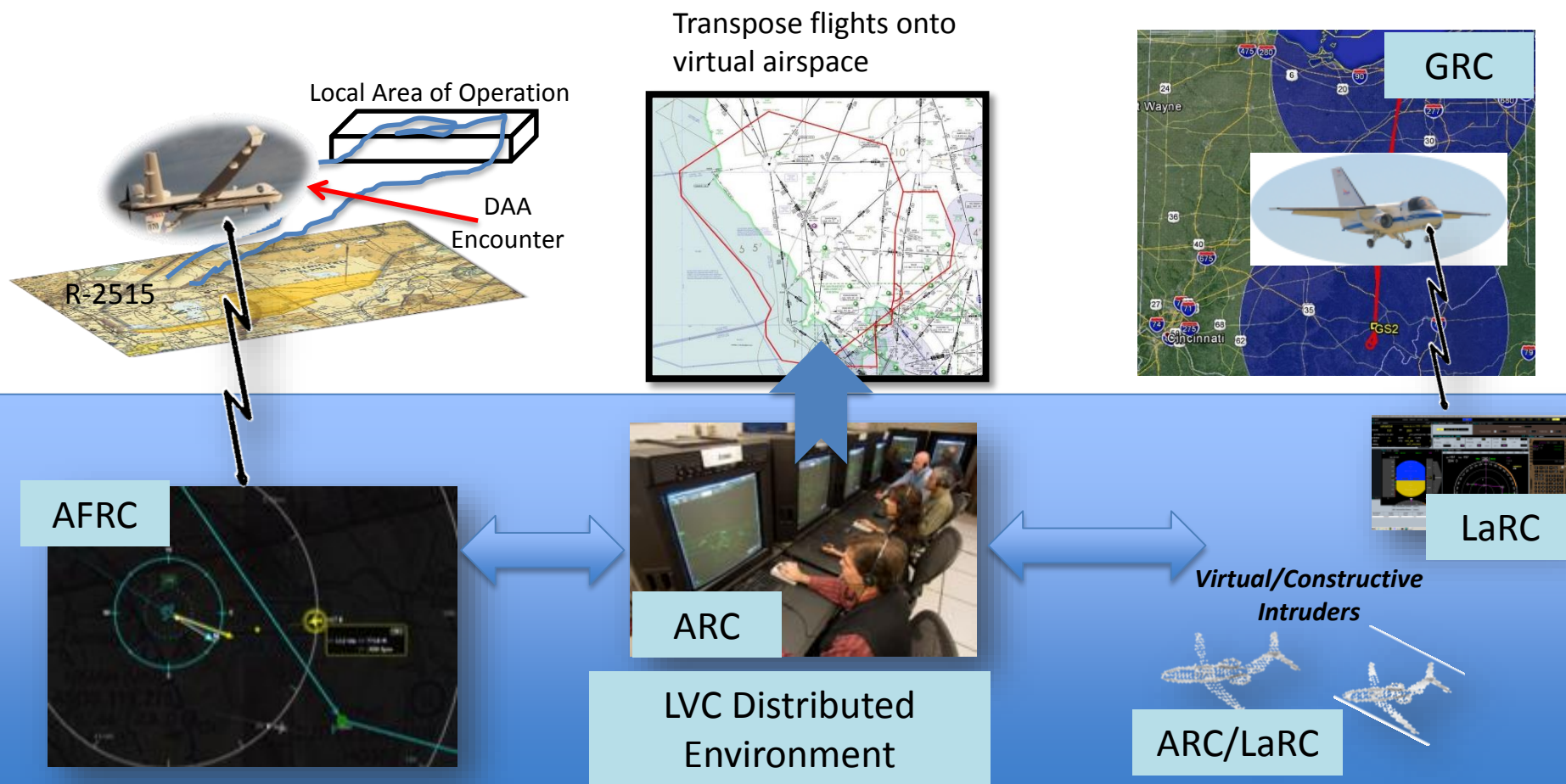


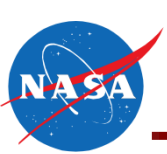
S-3B

LVC-DE



- Fly live aircraft out of AFRC and GRC, translated into a virtual airspace
 - Virtual background traffic from LaRC
 - ATC from ARC
 - Stream video across all 4 centers
- Conduct checkout flights and full rehearsal in conjunction with FT4 and C2 testing





Future Project Planning

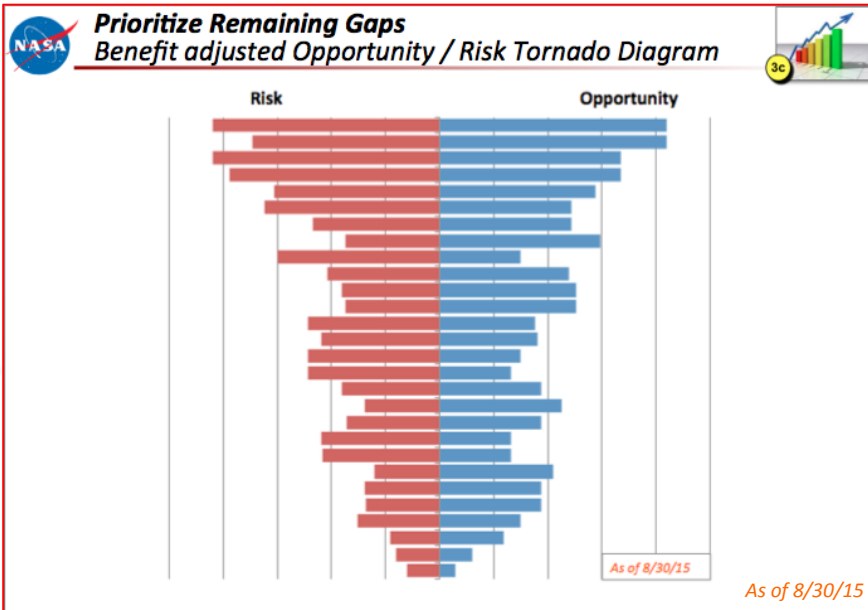
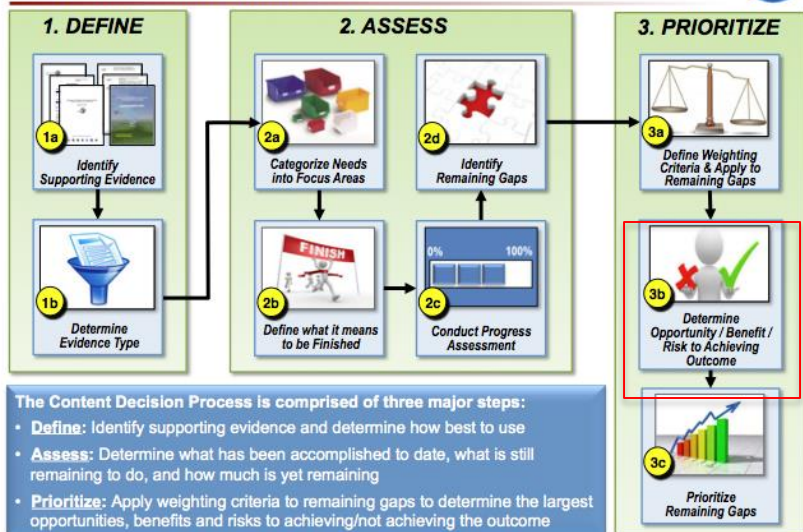


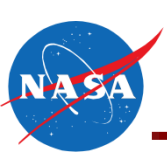
- Background: Project Baseline
 - The Phase 1 MOPS UAS-NAS Project baseline incorporated a roll-off of personnel Q4 FY16, and then leveraged Q1 FY17 to complete the project and required reporting
- Current FY16 plans
 - The project must burden current resources in FY16 to transition into P2 MOPS due to current cost/risk/schedule
 - FY16 reserves are being allocated to support FT4
 - FY16 resources are being adjusted to transition for effective execution of P2 MOPS support
 - P2 MOPS RFI/RFP development for partnerships (primarily C2 and DAA)
 - Content Decision Process planning leverages Full UAS Integration Analysis
- Activity may synchronize with planning for other UAS Full Integration Projects

Full UAS Integration Update

- Full UAS Integration Analysis is intended to provide a systematic means for ARMD to evaluate UAS research areas and assist in portfolio decisions
- FY15 analysis updates include
 - Source documentation updated to reflect current industry needs
 - Developed “100% complete” definition for all sub bins
 - Gap analysis performed for all bins
 - Opportunity/Risk/Benefit process for all Gaps refined through ARMD meetings
 - Lead, Collaborate, Leverage ground work laid
- Initial familiarization and coordination across NASA ARMD
 - ARMD Analysis Board
 - UTM Project Manager inputs
- MOE process (agenda, attendees, goals, etc) defined and ready to vet within NASA ARMD

ARMD UAS Full Integration Portfolio Prioritization Process

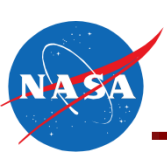




Future Project Planning Resources



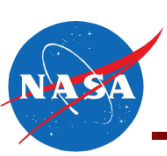
- Planning Resources
- Risk to Potential early investment activities due to Project reserve availability
 - RFI/RFP develop and execution
 - DAA/C2 trade studies
 - DAA/C2 early procurement activities
- Other ARMD uses of UAS Full Integration Analysis would cause additional impacts



Outline



- UAS-NAS Overview
- Technical Challenge Performance
- Non-Technical Challenge Work
- **Project Processes Implementation – Davis Hackenberg**
 - Project Rigor
 - Significant Changes against Baseline
 - Risk Management
 - FT3 Example
- Project Level Performance & FY16 Look Ahead
- Review Summary



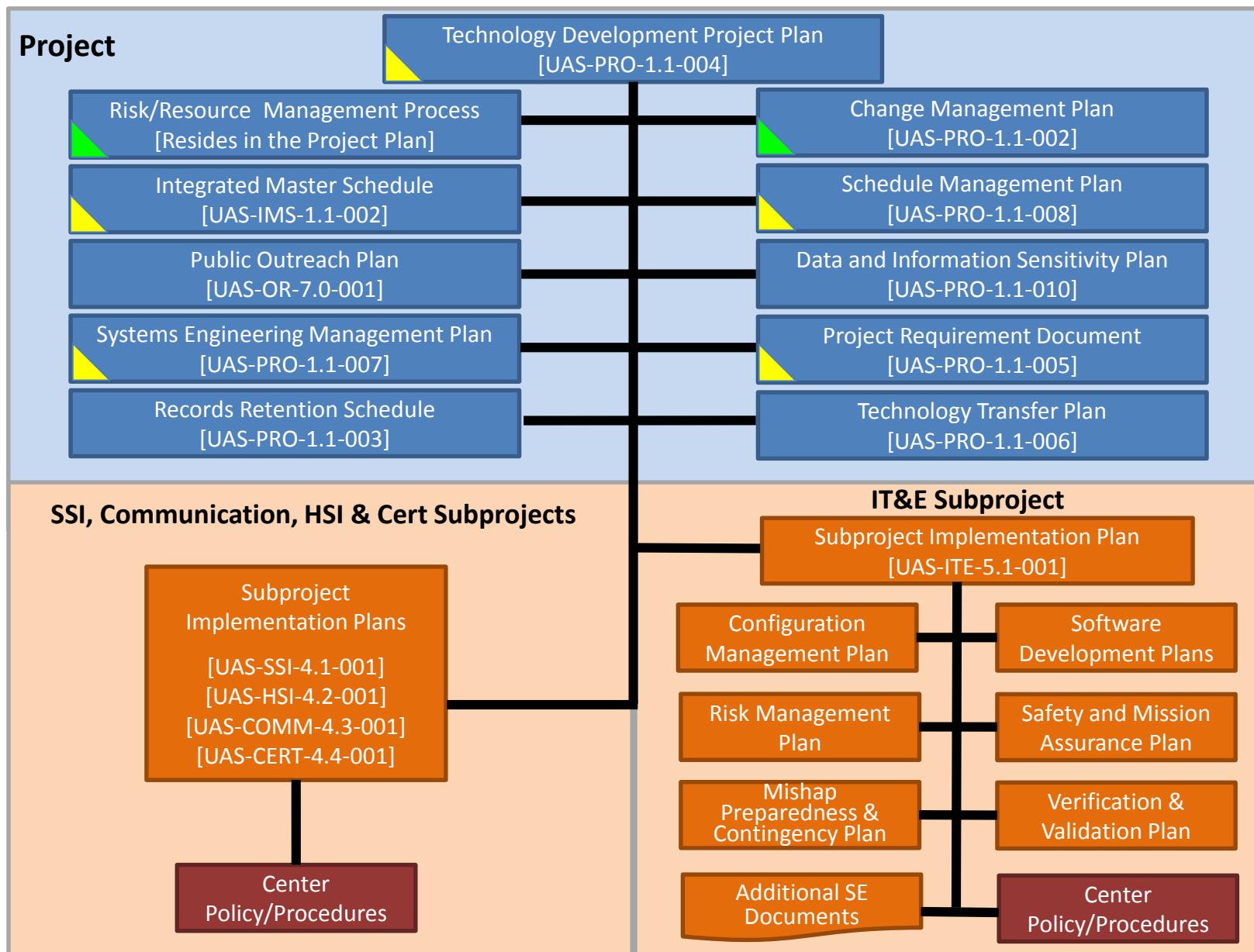
Project Rigor



- Due to the limited lifecycle of the Project, and importance of delivering commitments on time, the project has implemented rigorous management processes
- Rigor was re-evaluated and outcomes presented at the FY14 Annual Review
 - The project took steps to balance rigor with other time/overhead burdens
 - The Project team supported and understood the need for rigor
- The Project processes
 - Were instrumental in FY15 successes
 - Had room for improvement in FY15
- A review of the project processes with a focus on FT3 provides insight into process strengths and weaknesses

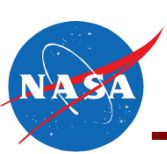


Project Document Tree



Primary processes leveraged by examples

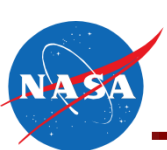
Secondary processes leveraged in this section



Significant Changes against the Baseline



- TC-SAA: Schedule Package Changes
 - Closed/eliminated SP S.3.20, “Well Clear Alerts/Resolutions with VFR and Pilot/Controller (ACES Simulation)” and added SP S.3.30, “Well Clear Alerting Logic, Methods, and Performance Requirements” to provide greater benefit to SC-228 by conducting work of greater importance to SC-228
- TC-ITE: FT3 Completion
 - FT3 completion change request was primarily based on completion of FT3 Config 1 (11 flights) on July 24, 2015 and the decision to cease data collection for Config 2 (8 system checkout flights and 3 data collection flights) on August 13, 2015. The L1 Milestone was closed on August 13, 2015
 - Deleted the FT3 related HSI research products and deliverables
- Non-TC: Certification L2 Milestone Deletion (off-ramp)
 - Goal Structured Notation (GSN) Safety case did not meet the original intent of the deliverable
- Non-TC: sUAS Addition of New Work (on-ramp)
- Project Office: Reserve Allocations
 - Multiple change requests to allocate Project Office reserves to Technical Challenge areas



UAS-NAS Top Risks



Risk Matrix

LIKELIHOOD	5					
	4					
	3			4.1.11 5.1.11		
	2			5.1.8 1.1.10 IASP 02		
	1					

CONSEQUENCE

Criticality	L x C Trend	Approach
High	Decreasing (Improving)	A - Accept RA - Raise
Med	Increasing (Worsening)	M - Mitigate E - Elevate
Low	Unchanged	W - Watch C - Close
	(T) Indicates a Top Risk	R - Research

	Current Risks 9/24/2015	Risks presented at FY14 Annual Review
Mitigate	12	26
Watch	5	3
*Top Risks	5 + (1 IASP)	7 + (1 IASP)

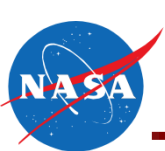
Risk ID	Trend	LxC	Target LxC	Approach	Risk Title
4.1.11	⇒	3x3	2x2	M	Validation of SAA Sensor Models
5.1.11	⇒	3x3	1x3	M	Required Assets for Flight Test 4 (FT4) not available during test period
5.1.8	⇒	2x3	1x3	M	Distributed Test Environment requirements for Integrated Flight Test 4 (FT4) not defined
1.1.10	↑	2x3	2x3	M	Output from Test Events has value to Project Stakeholders
IASP 02	⇒	2x3	1x1	M	Project Focus Changes Due to External Influences
1.1.12	NA	3x5	3x3	W	RTCA SC-228 Requirements Development Delay

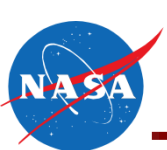
As of 9/30/15

- Changes Since FY14 Annual Review
 - Added 7 risks, closed 19 risks, and accepted 1 Risk
- Interdependent Project Risk
 - Asset availability - multiple

Process Successes and Areas for Improvement

FT3 Example

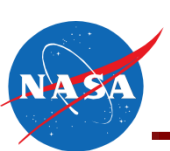




Outline

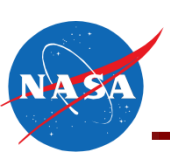


- UAS-NAS Overview
- Technical Challenge Performance
- Non-Technical Challenge Work
- Project Processes Implementation
- **Project Level Performance & FY16 Look Ahead – Laurie Grindle**
 - Resource Allocation and Utilization
 - Schedule
 - Requirements Summary
 - Partnerships and Collaboration
 - FY15 Accomplishments and FY16 Look Ahead
- Review Summary



Resource Allocation against Baseline Budget

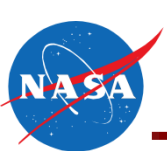




Resource Utilization FY15 Budget vs. Actuals Summary



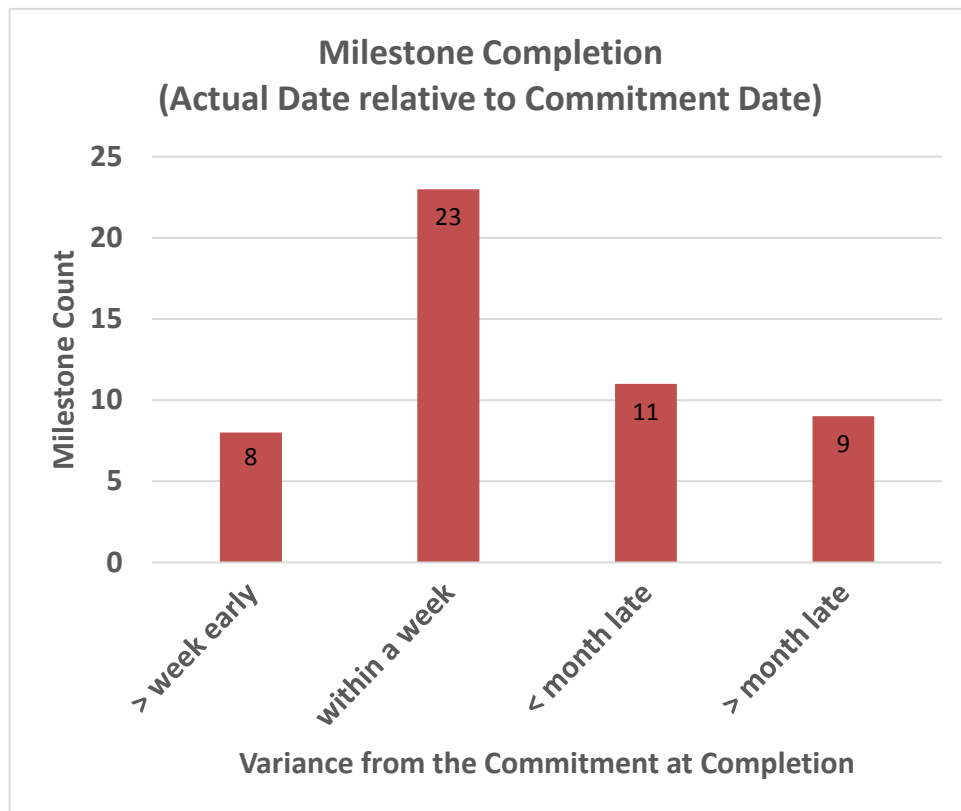
Successful Workforce and Resource Utilization



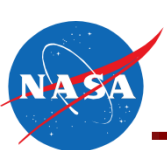
Non-WYE Funding



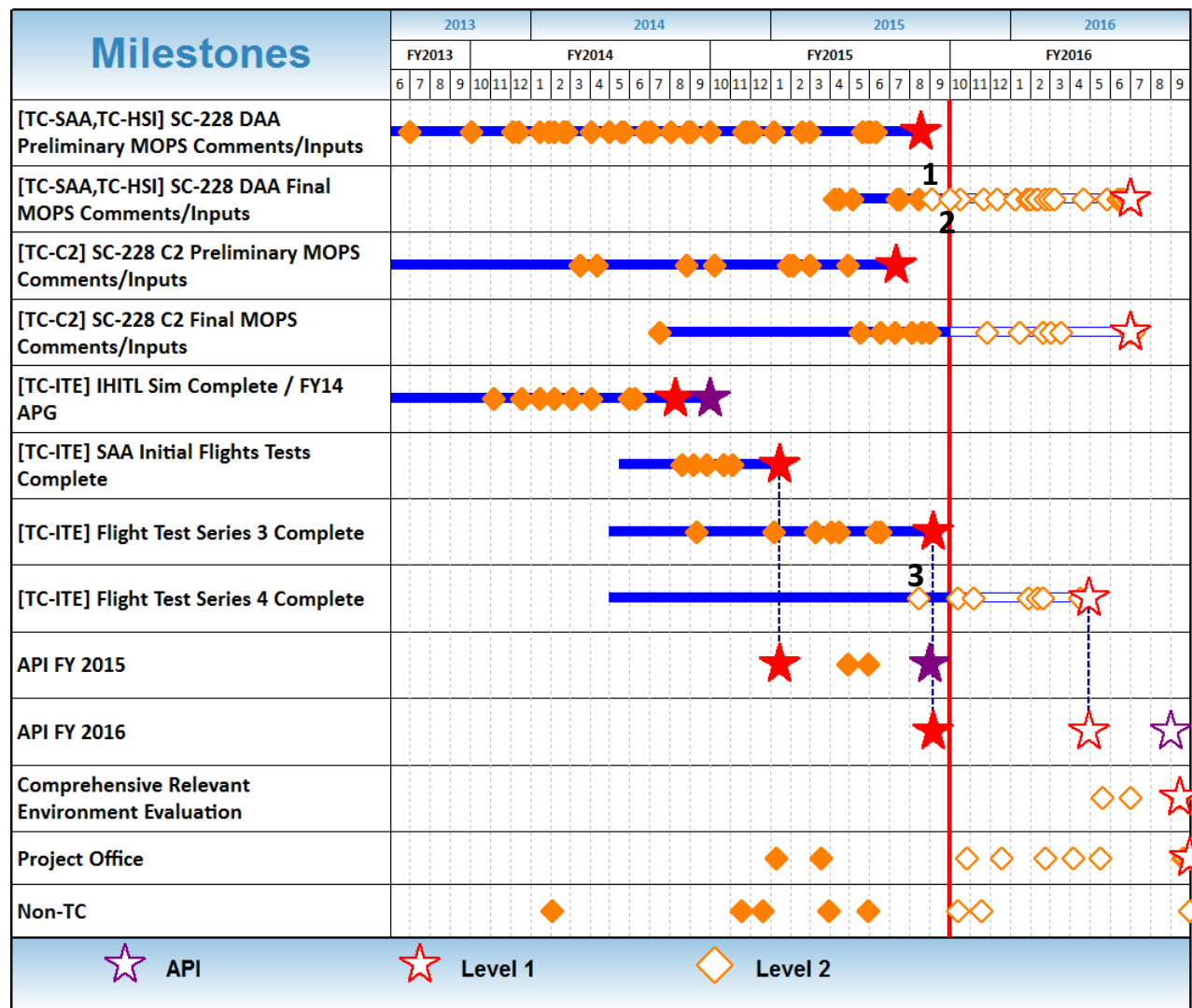
- FY15 Milestone Count
 - Planned FY15 Milestones: 54
 - Milestones completed in FY15: 51
- Causes of Milestone Delays
 - Issues identified during testing or preparation for testing
 - Test scope increased due to SC-228 additional requirements; results in:
 - Extended data collection
 - Extended analysis
 - Export control/release process exceeds planned duration
- Impacts of Milestone Delays
 - No impact to Preliminary DAA or C2 MOPS
 - Acceptable impact to downstream test/simulation activities



Successful Milestone Management



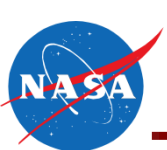
Milestone Summary



Red Status Line Date 9/30/15

Behind Schedule

1. "U6317 [SP S.1.20] Surveillance Requirements (Medium Fidelity) Brief results"
Commitment Date: 9/3/15
Estimated Date: 10/15/15
2. "U6826 [SP S.3.30] SAA Self Separating Alerting Methods, Performance, and Robustness Study Phase 2 - Document results in final report/briefing"
Commitment Date: 9/30/15
Estimated Date: 10/15/15
3. "U5597 [SP T.5.10] Capstone Test Requirements to Stakeholders"
Commitment Date: 8/14/15
Estimated Date: 10/2/15

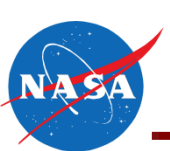


Project Requirements Summary



- **FY15 Status**
 - FY15: 18 Requirements completed
 - Project Total:
 - 30 Requirements completed
 - 45 Requirements remain
 - Total Requirements decreased from 76 to 75 during FY15
- **Four Requirements were deleted**
 - TC-SAA ACES Simulation Deleted
 - Capstone Planning Document
 - Standalone FT4 Test Plan
 - Report on the HSI results from FT3
- **Three Requirements were added**
 - Comprehensive Research Report
 - TC-SAA ACES Simulation Added
 - Created a combined FT4 Test Plan and Capstone Planning Document
- **Impacts of Requirements Changes**
 - No significant impact as a result of these changes

TWP	End of FY14	End of FY15	FY15 Completed	Total Completed
SAA	29	29	6	10
C2	17	17	5	6
HSI	13	12	2	6
ITE	13	12	3	6
PROJ	4	5	2	2
Total	76	75	18	30



Current and Anticipated Partnership Issues



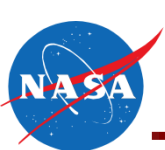


Current Active Collaborations/Partnerships Status



Partner (Project Area)	Agreement In Place	Collaboration/ Partnership Role
AFRL (TC-HSI)	Task Order	Coordinate activities on Vigilant Spirit Control Station. Status: On-going collaboration with AFRL supporting use of VSCS on HSI activities
Dragonfly Pictures (Non-TC-Certification)	SAA	Supporting the UAS certification case study by supplying the design of a UAS rotorcraft Status: Agreement in place for in-kind work, on-going
FAA UAS IO (Project Office)	MOA	Support by FAA leadership, management, and technical SMEs to validate work being done by the Project Status: On-going coordination of Project deliverables
FAA R&D Integration (Project Office)	MOA	Formal host of partnership agreements and collaborator for Integrated Test Activities Status: On-going coordination of Project deliverables
FAA TCAS Program Office (ACAS Xu) (TC-SAA)	Software	Coordinating on collaboration for ACAS-Xu software and associated flight tests Status: Successful SAA Initial Flight Tests
FAA UAS Test Sites (Project Office)	IDIQ Contract	Support of Task 1, UTM, and support of Task 2, LVC-DE efforts
General Atomics (TC-ITE)	SAA	Ikhana equipped with avionics and Proof of Concept SAA system directly supported by UAS-NAS Project Status: Agreement in place with GA for SAA Initial Flight Test and FT3 and FT4 for in-kind support

Purple text indicates changes since FY14 AR

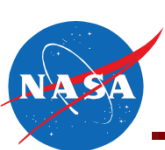


Current Active Collaborations/Partnerships Status



Partner (Project Area)	Agreement In Place	Collaboration/ Partnership Role
Honeywell (TC-ITE)	Contract	Sensor data fusion support Status: Supported FT3. Provided a Traffic alert and Collision Avoidance System (TCAS) II and ADS-B equipped intruder aircraft.
NASA SASO (Project Office)	NA	Coordination with AOSP on UTM and other activities Status: Collaborative effort working with FAA Test Sites
OSD SAA SARP (Project Office)	NA	Assess SAA research gaps and generate recommendations to RTCA SC-228. Status: Project serves as board member for SARP. Project actively participates in SARP activities
Rockwell Collins (TC-C2)	Cooperative Agreement	CNPC radio development and flight test. Cost sharing with Rockwell Collins concentrated in FY11-13, totaling \$3M contribution from Rockwell. Status: Rockwell Collins delivered Gen-4 and Gen-5 radios
RTCA SC-228 (TC-C2, TC-SAA)	NA	Conduct modeling, simulation and analysis to support the development of MOPS Status: On-going support to DAA and C2 working groups
NASA SMART NAS (Project Office)	NA	Coordination with SMART NAS Project on FY15 Augmentation tasks Status: Collaborative effort working on LVC/SMART NAS enhancements
UND (Non-TC-Certification)	SAA	Exploring requirements for safe operation of UAS through a series of case studies, experiments and flight evals. Status: On-going collaboration and in-kind support
University of South Carolina (TC-C2)	Grant	Develop channel models from RF channel sounding data and analysis of flight test data for channel fading and multipath effects.

Purple text indicates changes since FY14 AR



FY15 Accomplishments & FY16 Look Ahead



FY15 Accomplishments

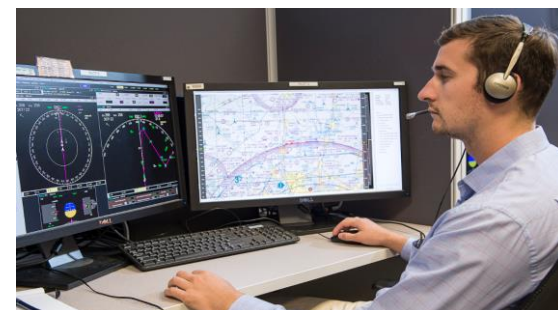
- Supported RTCA SC-228 and contributed to DAA and C2 Preliminary MOPS
- NASA IDIQ contract with all 6 FAA UAS Test Sites Established
- TC-SAA, TC-HSI, TC-ITE: SAA Initial Flight Test Successfully Executed
- TC-HSI, TC-SAA, TC-ITE: Part Task Simulation 5 Successfully Executed
- TC-C2: CNPC Gen-4 Flight Test Successfully Executed
- TC-SAA: CASSAT Successfully Executed
- TC-SAA: ACES Simulations Successfully Completed
- Non-TC [Cert]: Restricted Category Type Certification Report Successfully Completed
- Non-TC [sUAS]: Video Data Base Flight Test Successfully Executed
- NASA Honor Awards: ACAS-Xu and Self-Separation Group Achievement Award (TC-SAA, TC-HSI & TC-ITE), Langley Group Achievement Award (TC-SAA), Exceptional Leadership Award (TC-ITE), Exceptional Service Medal (PO, TC-HSI), Early Career Achievement Medal (PO)
- NASA X UAS-NAS Project Video won the Capital Region Emmy Award within the Informational/Instructional Category



Original Configuration

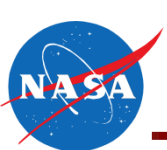


GA-ASI DRR Installed



FY16 Look Ahead

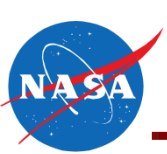
- TC-SAA, TC-C2, TC-HSI, TC-ITE: Flight Test Series 4
- TC-HSI, TC-SAA: Part Task Simulation 6
- TC-C2: CNPC Gen 5 Flight Test



FY16 Potential Storm Clouds



- FY16 Project Portfolio
 - Under examination to assess if original baseline plans have the right priorities
 - Working with SC-228 leadership for their prioritization of planned activities
- Major Test Activities
 - Flight Test Series 4 (FT4)
 - Path forward in work following decision to cease FT3 full mission data collection
 - Multiple options for full mission ownership
 - Potential Technical, Cost, Schedule impacts
- FY16 API
 - FT3 & FT4 execution and subsequent research findings contribute to the FY16 API
- SC-228
 - Stakeholder interest in Project test activities may impact FY16 Research Portfolio
- Resource Impact
 - FT4 path forward execution still in work; potential to exceed baseline budget
 - Potential IT&E workforce impact as a result of FAA UAS test site activities
- Potential Phase 2 MOPS Support Follow-on Project
 - Planning may impact FY16 Project baseline execution

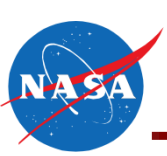


FY15 Summary

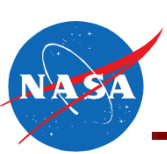


- ✓ Successful execution of Project Phase 2 Portfolio
 - Executed multiple ground tests, simulations, and flight tests
 - FY15 Annual Performance Indicator (API)
- ✓ Balanced rigor with timely and effective project management
 - Incorporating process lessons learned
- ✓ Enhanced LVC distributed test environment with augmentation spending
- ✓ Integral member of RTCA SC-228

***Delivered research findings and subject matter expertise
integral to DAA and C2 Preliminary MOPS***



UAS-NAS Overview Backup Slides



Phase 2 Content Decision Process



- **Step 1: Identify Community Needs**

- The Community Needs were collected from several strategic guidance documents that identified challenges preventing civil and commercial UAS from routinely operating within the NAS



- **Step 2: Define and Apply Filters**

- Filters were selected to assess which community needs were relevant to NASA, ARMD, and the Project
- Filters: *NASA & ARMD Mission, ARMD Skills/Capabilities, Project Time Frame*



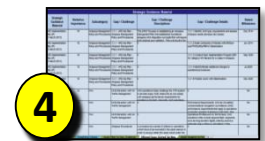
- **Step 3: Map to Focus Area Bins**

- Community needs that made it through the filters were binned into affinity groups



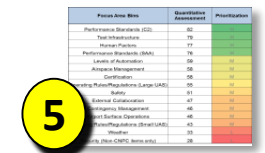
- **Step 4: Team Refine Sources and Bin Mapping**

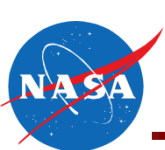
- Top Down (Project Office) and Bottoms Up (PEs & DPMfs) approaches come together to achieve consensus on sources and bins



- **Step 5: Applying Weight Criteria and Prioritization**

- Prioritization used to identify lower priority community needs that the Project should not pursue for Phase 2
 - Weighting Criteria: *Community Needs, Appropriate Organization, Ability to Complete, Complexity & Testing, Public Outreach/Acceptance*



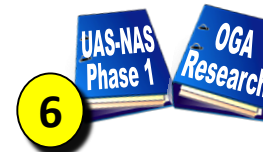


Phase 2 Content Decision Process (cont.)



- **Step 6: Community Progress Assessment**

- Evaluates the progress made towards addressing the community needs by NASA and other government/industry organizations to identify the remaining gaps



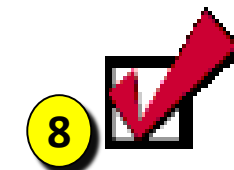
- **Step 7: Team Identify Technical Work Packages**

- Project Managers and Technical Leads provided assessments of which community needs the Project should be contributing towards in Phase 2



- **Step 8: Project Office Validate Proposed Technical Work Packages**

- The Project Office reviewed the proposed TWPs supplied by the team and evaluated them according to many factors including: Consistency with existing Phase 1 plans, lessons learned, and Phase 2 Drivers



- **Step 9: Develop Detailed Plans for Validated Technical Work Packages**

- Project Managers and Technical Leads developed detailed proposals for TWPs that address the UAS Community Needs



- **Step 10: Perform Cost, Benefit, and Risk Analysis for all Potential P2 Work**

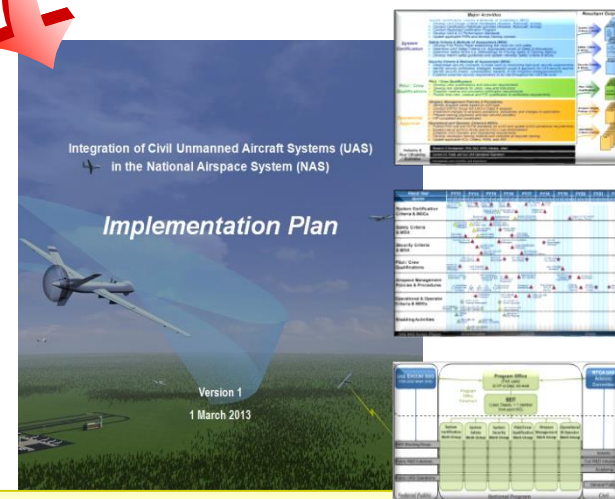
- The Project Office evaluated each Technical Work Package in the areas of cost, benefit, and risk to generate an initial portfolio
- Initial portfolio was evaluated for additional considerations, including: Support of Phase 2 Drivers, UAS Subcommittee Feedback, and results of the Center Independent Cost Assessments



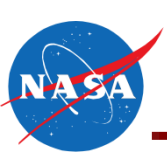
- The *FAA Concept of Operations (CONOPs) and Roadmap* establish the vision and define the path forward for safely integrating civil UAS operations into the National Airspace System (NAS)
- The *Civil UAS Implementation Plan* builds upon the FAA CONOPs and Roadmap by defining:
 - The FAA Aviation Rule Making Committee (ARC) view of the activities needed to safely integrate UAS
 - An initial plan for means, resources and schedule necessary for the aviation community and stakeholders to safely and expeditiously integrate civil UAS into the NAS
- NASA UAS Integration in the NAS Project Role
 - Leverage strategic material developed through the FAA (and partners) to ensure NASA portfolio will transfer to UAS integration
 - Continue partnership with the FAA to develop technologies and standards, and necessary planning material, throughout the life of the project



The FAA CONOPs & Roadmap establish the vision and define the path forward for Civil UAS Integration into the NAS



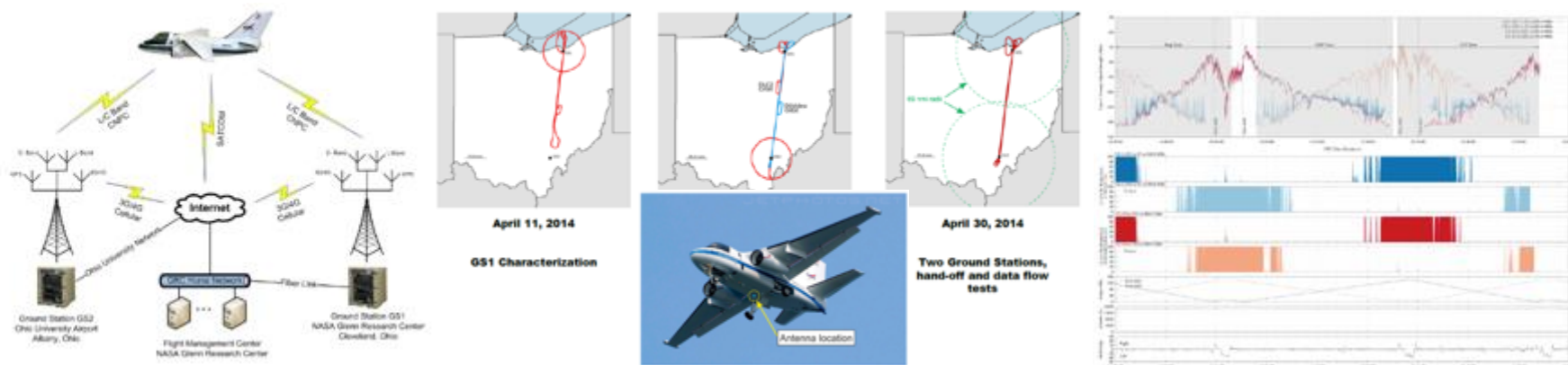
The Implementation Plan defines the means, resources, schedule, activities and structure for realizing the FAA CONOPs and Roadmap.



UAS-NAS Technical Challenge Performance Backup Slides

• Research Objectives:

- Analyze the performance of the second generation CNPC System prototype in a relevant flight environment



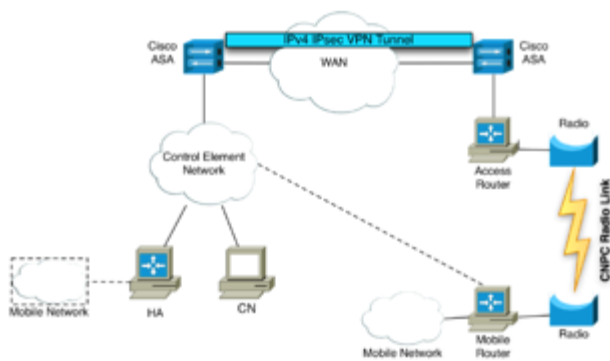
• Results and Conclusions:

- Demonstrated fluid transition “hand-off” of aircraft CNPC signal between two CNPC system ground stations
- Demonstrated operation of remote CNPC system ground terminals through network
- Measured data link transmission/reception times
- Testing of the 2nd generation CNPC system demonstrated the ability to meet the initial SC-203 performance goals
- Results from the test were analyzed and delivered to SC-228, providing validation data and technical basis for the draft C2 MOPS
- Flight Test Report was completed and released

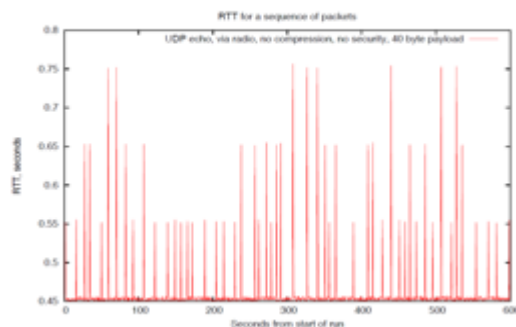
CNPC Radio for Development and V&V of C2 MOPS

- Research Objective:**

- Define CNPC security recommendations for civil UAS operations based on analysis of laboratory test results



Baseline Latency (UDP)



Results Summary

	Radio, Baseline	Radio, IPsec	Radio, ROHC	Radio, IPsec, ROHC
UDP Avg. Bytes/s	262.895	311.147	95.4017	219.03
ICMP RTT Avg., Sec	0.479911	0.490045	0.187938	0.387488
UDP RTT Avg., Sec	0.460836	0.461066	0.159071	0.357333
UDP RTT Min., Sec	0.451063	0.451097	0.151249	0.351076
UDP RTT Max., Sec	0.756798	0.85444	0.455316	0.655391
ICMP Std. Dev.	0.0399578	0.0454718	0.0491813	0.0447224
UDP Std. Dev.	0.0370915	0.0428625	0.0335293	0.0278838

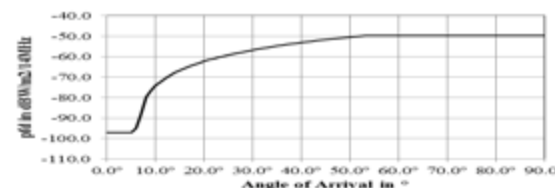
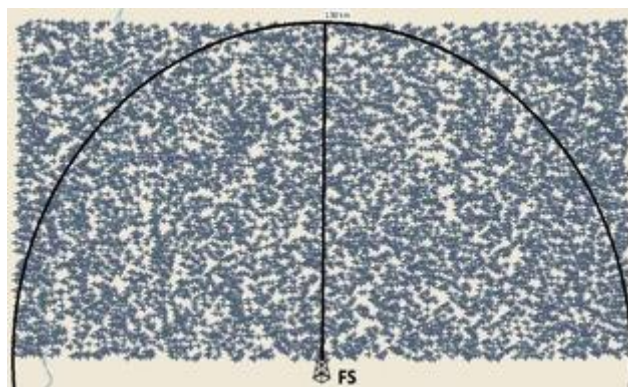
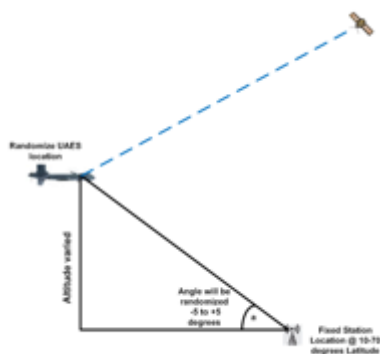
- Results, Conclusions, and Recommendations:**

- Implemented security mitigations identified in previous project studies
- Performed full end-to-end testing of system in laboratory environment, utilizing Gen-2 radio hardware
- Developed baseline for overhead and latency imposed by the recommended security measures
- Results from the test were analyzed and delivered to SC-228, providing validation data for the security portions of the draft C2 MOPS
- Test report was completed and released

CNPC System Security Requirements for C2 MOPS

- **Research Objective:**

- Develop data and rationale to obtain appropriate frequency spectrum allocations to enable the safe and efficient operation of UAS in the NAS



- **Interim Results, Conclusions, and Recommendations:**

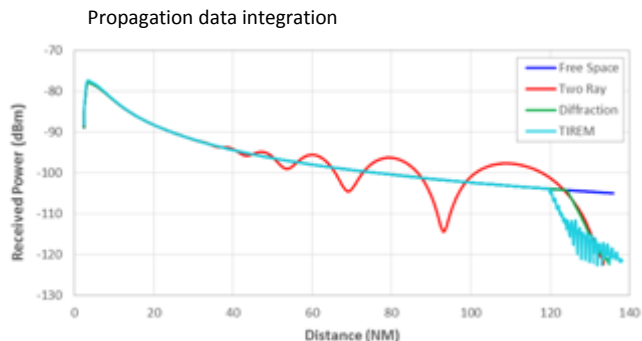
- Developed and delivered Annex 7 to ITU-R M.[UAS-FSS] report (Sharing studies on emissions from fixed satellite service earth station transmitters on-board unmanned aircraft into incumbent terrestrial services)
 - Conclusion is UA Fixed Satellite Service (FSS) transmitters do not cause Fixed Station (FS) protection criteria to be exceeded at altitudes $\geq 9\,000$ feet AGL and latitudes up to 70 degrees for 14.0-14.47 GHz
 - Conclusion is UA Fixed Satellite Service (FSS) transmitters do not cause Fixed Station (FS) protection criteria to be exceeded at altitudes $\geq 3\,000$ feet AGL and latitudes up to 70 degrees for 27.5-29.5 GHz
- Results are being delivered at the 2015 World Radiocommunication Conference to support the allocation of Ku & Ka Band frequencies for UAS operations

CNPC Frequency Spectrum Allocation Requirements for C2 MOPS

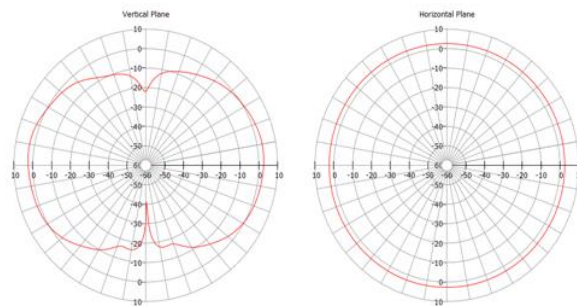
- **Research Objective:**

- Develop validated radio models, based on flight testing and development of performance profiles to be used during regional large scale simulations

Start of Data Collection May 2015



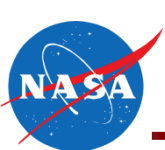
L-band antenna
models
characteristics



- **Interim Results, Conclusions, and Recommendations:**

- Update of radio models to Gen-5 FT radio implementation completed (early Sept) in Opnet
 - New CNPC Gen-5 waveforms and calibrations
 - New logic/messaging for CNPC connection establishment, authentication, waveform changes and handoffs
 - IPv6 with Mobility and Compression. Networked GS operation
 - CNPC data traffic profile changes by domain (airspace) and class (UA Class)
 - Inclusion of flight test propagation models data in Opnet
 - Inclusion of L-band ground antenna model characteristics
- Currently working integration of Gen-5 model and its supporting ground station infrastructure into large-scale simulation
- Model validation testing with Gen-5 radios is in progress in GRC lab

CNPC Radio Simulation Development for Development and V&V of C2 MOPS

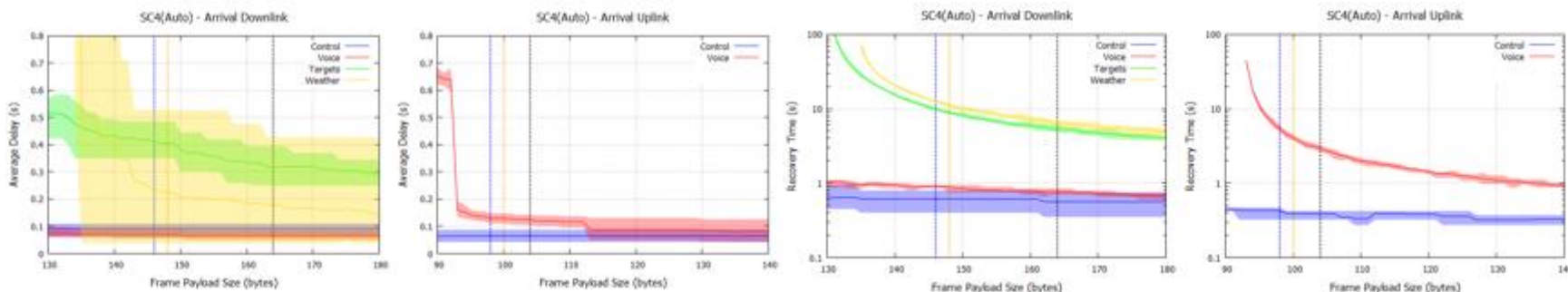


Recommendations for Integration of CNPC and ATC Comm



- **Research Objective:**

- Develop inputs to preliminary and final SC-228 C2 WG MOPS based on simulations conducted in OPNET and ACES Large-scale environments using specific MOPS and NAS Comm Architecture operations scenarios



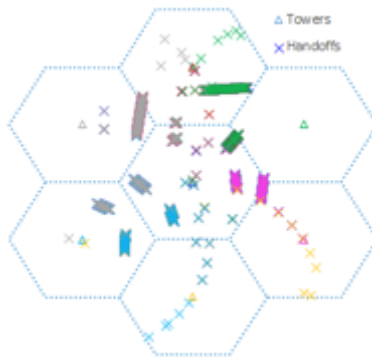
- **Interim Results, Conclusions, and Recommendations:**

- Completed simulations and delivered results to SC-228 C2 WG, to define parameters for Gen-5 V&V radio
- CNPC and ATC Comm integration simulations to be run in March 2016 with Gen-5 radio model
 - Simulation analysis will look at the ability/performance of ATC communications in providing continued piloted aircraft ATC with ATC required for UA aircraft operations. UA Classes above sUAS for ATC
 - Comparison of Relay vs. non-Relay architecture performance
 - Varied air-traffic scenarios for mixed operations
 - Evaluated for performance, safety, reliability

NAS-Wide CNPC System Simulation for Development and V&V of C2 MOPS

- **Research Objective:**

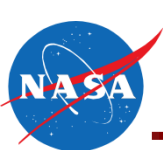
- Perform large-scale NAS simulations to assess impact of UAS on the NAS communications operations with different operating concepts and for different control and non-payload communication system architectures



- **Interim Results, Conclusions, and Recommendations:**

- Simulations are using Gen-5 Radio model
- Simulation analysis will look at the performance impact on NAS ATC communication, Datalink Communication and CNPC uplink and downlink for C2, Telemetry, Wx, DAA, and Navaid information handled over the CNPC link for varying air traffic loads
- Varied air-traffic scenarios for mixed operations
- Evaluate for performance, safety, reliability

NAS-Wide CNPC System Simulation for Development and V&V of C2 MOPS

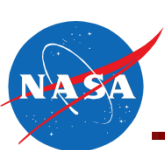


Gen2 Radio in Relevant Environment Flight Test



TC-C2 Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP C.1.10] Gen2 Radio in Relevant Environment Flight Test	4/2014	<ul style="list-style-type: none">Analyze the performance of the second generation C-band CNPC System prototype in a relevant flight environment	<ul style="list-style-type: none">Results continue the development of the CNPC system terrestrial operation performance standards

- Briefings, Papers, or Reports
 - UAS-Comm-4.3-025-001, CNPC Prototype Radio Development Generation 2 Flight Test Program Overview, Briefing, August 2014

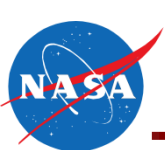


Verify Prototype Performance – Preliminary C2 MOPS Input



TC-C2 Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP C.1.20] Verify Prototype Performance - Draft C2 MOPS Input	1/2015	<ul style="list-style-type: none">Analyze the performance of the fourth generation C-band Control and Non-Payload Communication System prototype in a relevant flight environment	<ul style="list-style-type: none">Results inform:<ul style="list-style-type: none">Performance of CNPC System prototype in a Relevant, mixed traffic environmentDevelopment of a final, verified and validated, Command and Control Minimum Operational Performance Standards

- Briefings, Papers, or Reports

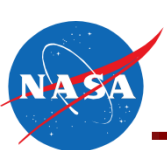


Verify Prototype Performance - Final C2 MOPS Input



TC-C2 Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP C.1.30] Verify Prototype Performance - Final C2 MOPS Input	6/2015 (FT3) 2/2016 (FT4)	<ul style="list-style-type: none">Analyze the performance of fourth generation Control and Non-Payload Communication System prototypes used for control and non-payload communication for a GCS implementing SAA algorithms and information display requirements controlling an unmanned aircraft surrogate operating in a mixed traffic environment	<ul style="list-style-type: none">Results inform:<ul style="list-style-type: none">Performance of CNPC System prototype in a Relevant, mixed traffic environmentDevelopment of a final, verified and validated, Command and Control Minimum Operational Performance Standards

- Briefings, Papers, or Reports
 - Compliance ITU-R Prototype Comm System: Report on Results from FT3 Simulation planned for November 2015 (FT3)
 - Compliance ITU-R Prototype Comm System: Final Report on Flight Test 4 (FY15) mixed traffic environment with 2nd vehicle planned for September 2016



Develop and Test Security Prototype



TC-C2 Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP C.2.10] Develop and Test Prototype	3/2014	<ul style="list-style-type: none">Define CNPC security recommendations for civil UAS operations based on analysis of laboratory test results	<ul style="list-style-type: none">Results inform understanding of CNPC system security architecture performance

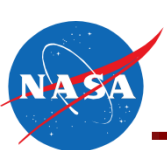
- Briefings, Papers, or Reports
 - UAS-Comm-4.3-015-001, Security Test Plan for Lab Prototype, January 2014
 - UAS-Comm-4.3-023-001, Control and Non-Payload Communications (CNPC) Prototype Radio – Generation 2 Flight Lab Security Test, Report, August 2014
 - UAS-Comm-4.3-026-001, CNPC Security Architecture Prototype, Briefing, August 2014



Performance Validation of Security Mitigations - Relevant Flight Environment

TC-C2 Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP C.2.20] Performance Validation of Security Mitigations - Relevant Flight Environment	10/2014	<ul style="list-style-type: none">Determine CNPC security recommendations for civil UAS operations based on analysis of flight test results	<ul style="list-style-type: none">Results:<ul style="list-style-type: none">Inform CNPC system security design requirementsInform control and non-payload security architecture performanceContribute to validation of security mechanisms designed to mitigate risks and vulnerabilities of CNPC system as incorporated in performance standardsInform understanding of CNPC system performance during hand-off between communication system ground stations and edge of coverage events

- Briefings, Papers, or Reports

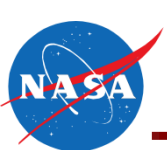


Spectrum Compatibility Analysis



TC-C2 Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP C.3.10] Spectrum Compatibility Analysis	Not applicable	<ul style="list-style-type: none">Develop data and rationale to obtain appropriate frequency spectrum allocations to enable the safe and efficient operation of UAS in the NAS	<ul style="list-style-type: none">Analysis:<ul style="list-style-type: none">Provides technical data on NASA UAS terrestrial CNPC developments to ICAO Aeronautical Communications Panel Working Group F to develop the technical parameters of the UAS LOS CNPC allocations and support international standards developmentProvides compatibility studies, in coordination with RTCA SC-228, to evaluate technical issues involved with the sharing of FSS spectrum for BLOS UAS CNPCInforms technical parameters for allocated UAS terrestrial spectrum, in International standards organizations

- Briefings, Papers, or Reports
 - UAS-Comm-4.3-024-001, GRC Spectrum Update, Briefing (SC-228), August 2014
 - UAS CNPC Spectrum Final Report and Recommendations planned for September 2016

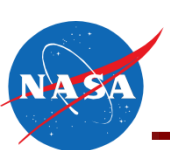


C-Band Planning & Standards



TC-C2 Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP C.3.20] C-Band Planning & Standards	Not Applicable	<ul style="list-style-type: none">Develop data and rationale to define usage of terrestrial spectrum for UAS CNPC systems to enable the safe and efficient operation of UAS in the NAS	<ul style="list-style-type: none">Results inform:<ul style="list-style-type: none">Technical parameters for allocated UAS terrestrial spectrum, in International standards organizationsDevelopment of C-Band band plans and standards, in coordination with RTCA SC-228 and delivered to ICAO Working Group F, to define usage of terrestrial spectrum for UAS CNPC systems

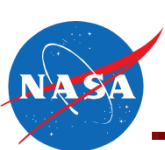
- Briefings, Papers, or Reports
 - UAS-Comm-4.3-016-001, Spectrum Element C-Band Planning and Standards Dev Plan, Paper, January 2014
 - C-Band Planning and Standards briefing to SC-228 planned for February 2016
 - C-Band Planning & Standards Final report planned for September 2016



Flight Test Radio Model Development and Regional Sims

TC-C2 Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP C.4.10] Flight Test Radio Model Development and Regional Sims	5/2015	<ul style="list-style-type: none">Develop validated radio models, based on flight testing and development of performance profiles to be used during regional large scale simulations	<ul style="list-style-type: none">Results inform:<ul style="list-style-type: none">Initial validation of proposed RTCA CNPC performance standards and to recommend necessary modifications prior to published C2 MOPS

- Briefings, Papers, or Reports
 - Flight Test Radio Model Development and Regional Sims Report planned for July 2016



Recommendations for Integration of CNPC and ATC Comm



TC-C2 Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP C.4.30] Recommendations for Integration of CNPC and ATC Comm	Multiple	<ul style="list-style-type: none">Develop inputs to preliminary and final SC-228 C2 WG MOPS based on simulations conducted in OPNET and ACES Large-scale environments using specific MOPS and NAS Comm Architecture operations scenarios	<ul style="list-style-type: none">Results inform:<ul style="list-style-type: none">Communication system performance and NAS-wide impact from large-scale NAS simulations incorporating UAS communication system and vehicle performance characteristicsValidation of proposed RTCA CNPC performance standards prior to published MOPSRecommendations for the integration of CNPC and ATC Comm

- Briefings, Papers, or Reports
 - Large Scale Sims to SC-228 for C2 Final MOPS draft report planned for June 2016
 - Recommendations for Integration of CNPC and ATC Comm report planned for September 2016

TC-C2 Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP C.4.40] Communication System Performance Impact Testing (Delays/Capacity)	8/2015	<ul style="list-style-type: none"> Perform large-scale NAS simulations to assess impact of UAS on the NAS communications operations with different operating concepts and for different control and non-payload communication system architectures 	<ul style="list-style-type: none"> Results inform: <ul style="list-style-type: none"> ATC and CNPC Communications Performance Impact on NASA Delays/Capacity

- Briefings, Papers, or Reports
 - ATC and CNPC Comm Performance Impact on NAS Delay/Capacity report planned for February 2016

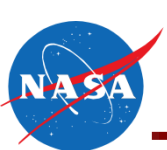


SatCom Simulations

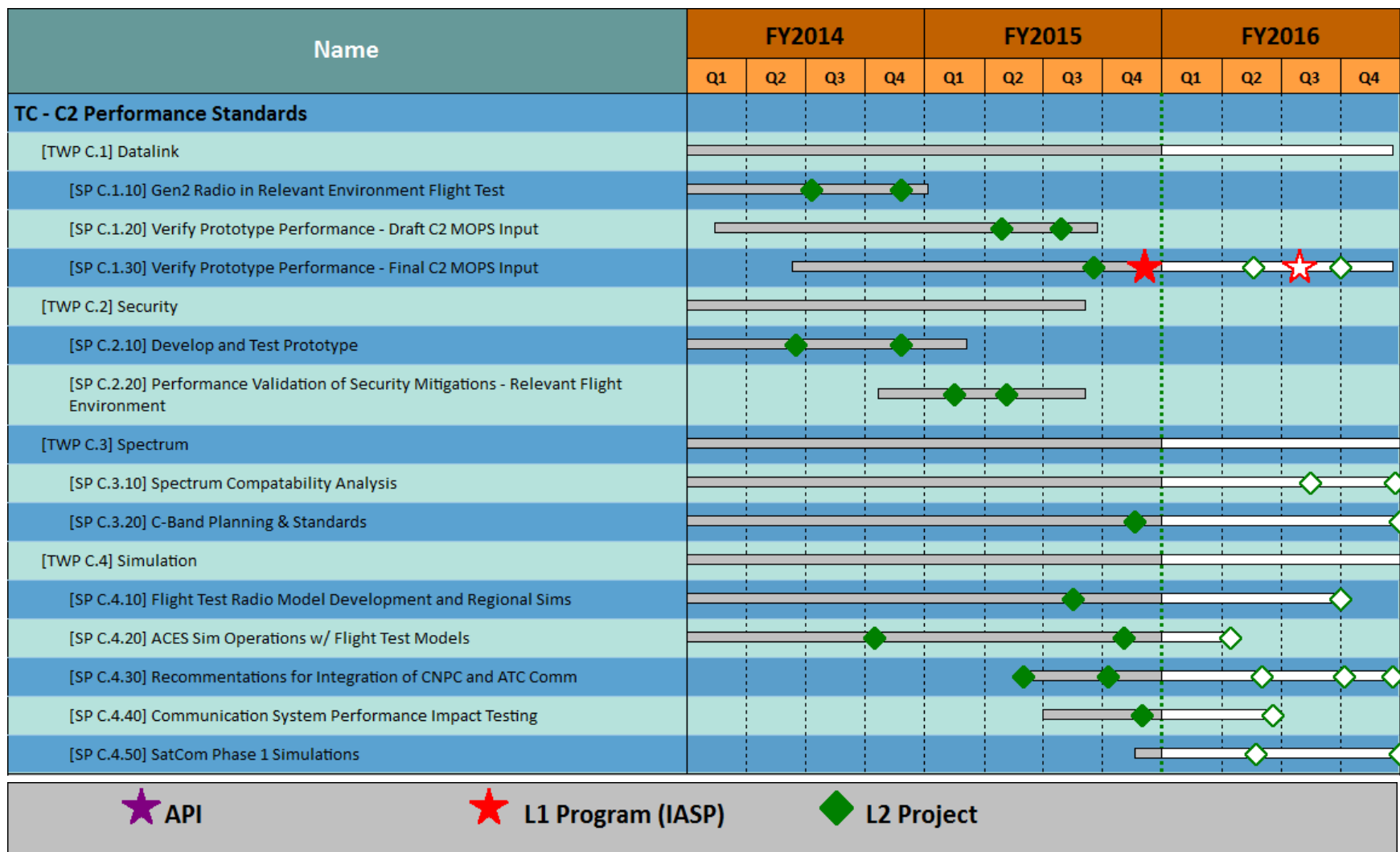


TC-C2 Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP C.4.50] SatCom Simulations	2/2016	<ul style="list-style-type: none">Analyze SatCom Control and Non-Payload Communication system using regional large scale simulations	<ul style="list-style-type: none">Results inform:<ul style="list-style-type: none">Satcom assumptions utilized in SC-228 C2 terrestrial MOPS and provides initial inputs to draft SC-228 C2 Satcom MOPS

- Briefings, Papers, or Reports
 - SatCom for UAS Sim Report planned for September 2016



TC – C2

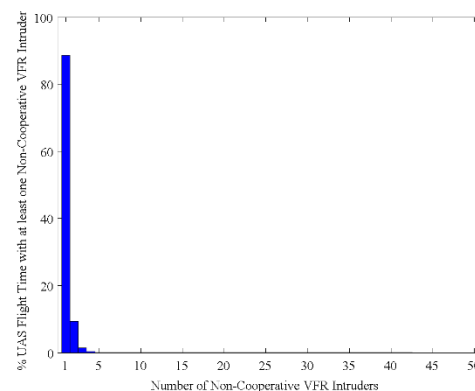
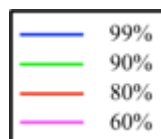
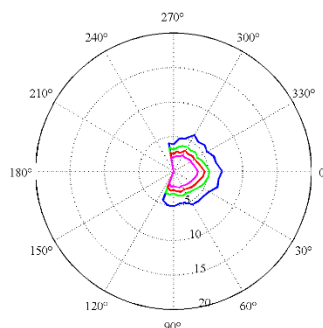


Green Status Line Date 9/30/15

- **Research Objective:**

- Analyze the performance of updated sensor (ADS-B, TCAS, and radar) range and fields of regard requirements and sensitivities against Draft MOPS Alerting requirements
- Assess airborne radar intruder detection frequency against realistic NAS traffic (IFR, cooperative VFR, and non-cooperative VFR) to inform radar tracker requirements

Preliminary:



- **Interim Results, Conclusions, and Recommendations**

- 5-nm range appears to cover 99% of potential warning alerts DAA system would encounter with non-cooperative VFR providing verification that 5-nm declaration range for airborne radar is suitable (Preliminary Result)
- When UAS had at least one non-cooperative VFR intruder in its field of regard, there were 3 or fewer non-cooperative aircraft 98% of the time (Preliminary Result)

Non-Cooperative Sensor Surveillance Requirements for DAA MOPS

- **Research Objective:**

- Test Setup 1: Evaluate air traffic controller acceptability of UAS maneuvers in response to SAA advisories and pilot performance for remaining Well Clear
- Test Setup 2: Evaluate the pilot's ability to remain well clear as a function of detect-and-avoid display features and whether the display was stand-alone or integrated within the main traffic display



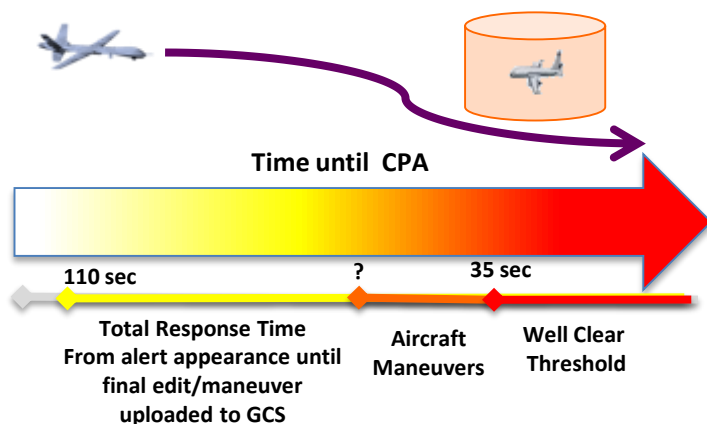
- **Results, Conclusions, and Recommendations:**

- Test Setup 1
 - Controllers reported maneuvers requested between 60 and 90 seconds until closest point of approach were acceptable, and at 120 seconds were unacceptable.
 - Size of requested maneuvers was frequently judge to be too large, indicating a difference between the separation standard used by UAS pilots to remain Well Clear and manned aircraft.
- Test Setup 2
 - Maneuver recommendations appear to be the 'Advanced' feature most effective in remaining Well Clear
 - Although non-cooperative aircraft can only be detected at a limited range, most losses of Well Clear can be prevented given alert time of at least 60 seconds to closet point of approach
 - Pilot response time results will help improve fidelity (ATC/UAS pilot interactions) of non-real-time-time simulations

ATC Interoperability Requirements for DAA MOPS

Research Objective:

- Estimate the achievable DAA self separation risk ratio under simplifying assumptions on pilot response and surveillance capabilities.
- To identify necessary capabilities improvements for assessing draft MOPS requirements in future studies.



Run #	SST time to LoWC (sec)	LoWC Prediction HMD/DMOD (incl. buffer) (ft.)	HMD Resolution Buffer
1	40s	4000 ft.	10%
2	70s	4000 ft.	10%
3	40s	5000 ft.	10%
4	70s	5000 ft.	10%
5	40s	4000 ft.	20%
6	70s	4000 ft.	20%
7	40s	5000 ft.	20%
8	70s	5000 ft.	20%

Results, Conclusions, and Recommendations:

- Resolution horizontal miss distance buffer had negligible impact on Risk Ratio (may need larger buffers)
- Increasing self-separation threshold demonstrated greatest Risk Ratio reduction : Highlights importance of pilot response modeling to DAA risk ratio estimation
- Increasing predicted HMD/DMOD showed modest risk ratio reduction: poor risk ratios for no buffer case (4,000 feet prediction HMD/DMOD)... points to importance of prediction buffers

Self-Separation System Performance Requirements for DAA MOPS

- **Research Objective:**

- Gather data on the performance of a SAA concept with flight representative trajectory uncertainties, control and non-payload communication system characteristics, vehicle dynamics, and SAA sensors in order to improve and calibrate simulation models



Research GCS



Displays of Proximal Traffic
SAA/DAA Algorithms



AFRC Ikhana

Live Intruder

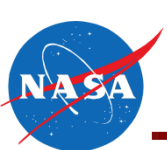
- ADS-B
- TCAS II Instm
- High speed



- **Results, Conclusions, and Recommendations:**

- Test complete
- Data analysis is on-going

Self-Separation System Performance Requirements for DAA MOPS



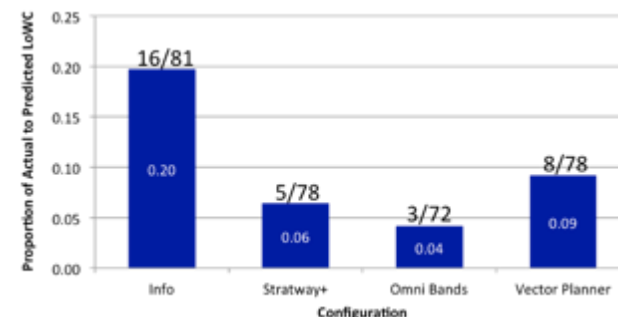
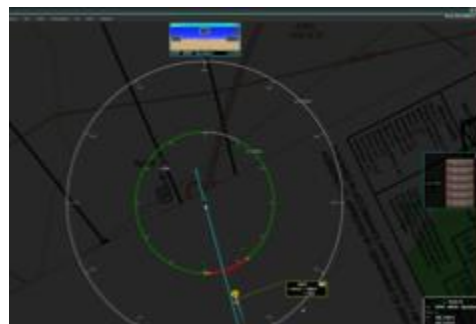
SAA Traffic Display Evaluation HITL2 (joint w/HSI Part Task Sim 5)



Research Objective:

- Build upon previous human-in-the-loop simulations results and lessons learned to identify minimum DAA display and guidance requirements for draft SC228 MOPS
- Evaluate pilot's ability to remain well clear when considering sensor uncertainty, Preliminary MOPS alerting structure, and DAA guidance mode (informative vs. suggestive)






Symbol	Name	Pilot Action	Buffered Well Clear Criteria	Time to Loss of Well Clear	Aural Alert Verbiage
	Self Separation Warning Alert	<ul style="list-style-type: none"> Immediate action required Notify ATC as soon as practicable after taking action 	DMOD = 0.75 nmi HM0 = 0.75 nmi ZTHR = 450 ft modTau = 35 sec	25 sec (TCPA approximate: 60 sec)	"Traffic, Maneuver Now"
	Corrective Self Separation Alert	<ul style="list-style-type: none"> On current course, corrective action required Coordinate with ATC to determine an appropriate maneuver 	DMOD = 0.75 nmi HM0 = 0.75 nmi ZTHR = 450 ft modTau = 35 sec	75 sec (TCPA approximate: 120 sec)	"Traffic, Separate"
	Preventive Self Separation Alert	<ul style="list-style-type: none"> On current course, corrective action should not be required Monitor for intruder course changes Talk with ATC if desired 	DMOD = 0.75 nmi HM0 = 1.0 nmi ZTHR = 700 ft modTau = 35 sec	75 sec (TCPA approximate: 120 sec)	"Traffic, Monitor"
	Self Separation Proximity Alert	<ul style="list-style-type: none"> Monitor target for potential increase in threat level 	DMOD = 0.75 nmi HM0 = 1.5 nmi ZTHR = 1200 ft modTau = 35 sec	85 sec (TCPA approximate: 120 sec)	N/A
	None (Target)	<ul style="list-style-type: none"> No action expected 	Within surveillance field of regard	X	N/A

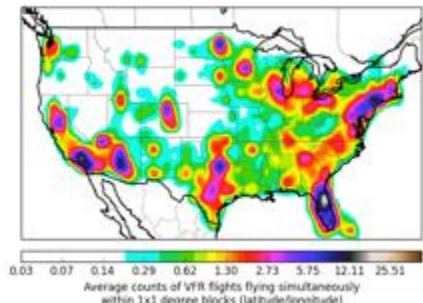


Results, Conclusions, and Recommendations:

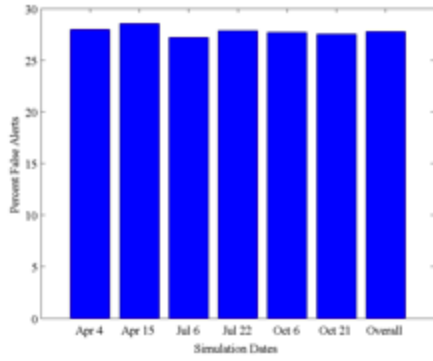
- Info Only (19.8%) was roughly *four times* as likely as Stratway+ (6.5%) and Omni Bands (4.2%) to result in Loss of Well Clear, a significant difference ($p < .05$)
- No significant differences seen between the three guidance displays in terms of Loss of Well Clear
- Pilots responded, on average, 10 seconds faster to Self Separation Warning Alerts than they did to Corrective Self Separation Alerts
- Positive subjective feedback from pilots on Preliminary MOPS Alerting methodology

Self-Separation Sensor Performance Requirements for DAA MOPS

- Research Objective:**
 - Gather data to support development of alerting logic, methods, and performance requirements using cooperative and non-cooperative VFR traffic and the SC-228 definition of Well Clear considering target level of safety and NAS-interoperability
- | Symbol | Name | Pilot Action | Buffered Well Clear Criteria | Time to Loss of Well Clear | Aural Alert Verbiage |
|--|----------------------------------|---|---|---------------------------------------|-------------------------|
|  | Self Separation Warning Alert | <ul style="list-style-type: none"> Immediate action required Notify ATC as soon as practicable after taking action | DMOD = 0.75 nmi
HMD = 0.75 nmi
ZTHR = 450 ft
modTau = 35 sec | 25 sec
(TCPA approximate: 60 sec) | "Traffic, Maneuver Now" |
|  | Corrective Self Separation Alert | <ul style="list-style-type: none"> On current course, corrective action required Coordinate with ATC to determine an appropriate maneuver | DMOD = 0.75 nmi
HMD = 0.75 nmi
ZTHR = 450 ft
modTau = 35 sec | 75 sec
(TCPA approximate: 130 sec) | "Traffic, Separate" |
|  | Preventive Self Separation Alert | <ul style="list-style-type: none"> On current course, corrective action should not be required Monitor for intruder course changes Talk with ATC if desired | DMOD = 0.75 nmi
HMD = 1.0 nmi
ZTHR = 700 ft
modTau = 35 sec | 75 sec
(TCPA approximate: 130 sec) | "Traffic, Monitor" |
|  | Self Separation Proximity Alert | <ul style="list-style-type: none"> Monitor target for potential increase in threat level | DMOD = 0.75 nmi
HMD = 1.5 nmi
ZTHR = 1200 ft
modTau = 35 sec | 85 sec
(TCPA approximate: 120 sec) | N/A |
|  | None (Target) | <ul style="list-style-type: none"> No action expected | Within surveillance field of regard | X | N/A |



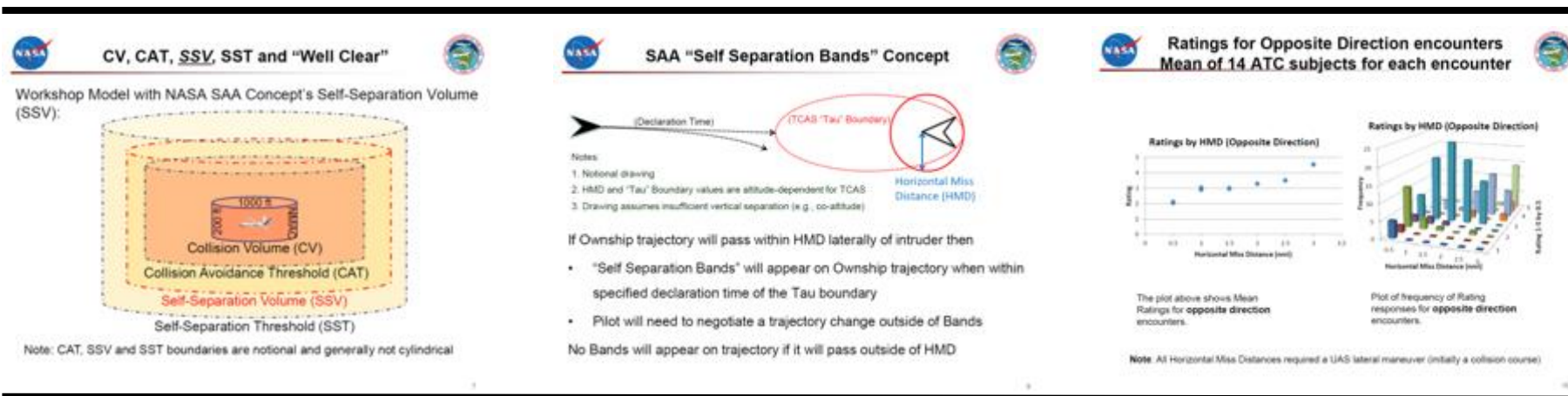
Average counts of VFR flights flying simultaneously within 1x1 degree blocks (latitude/longitude)



Simulation Dates	Percent False Alerts
Apr 4	~28
Apr 15	~29
Jul 6	~27
Jul 22	~28
Oct 6	~28
Oct 21	~28
Overall	~28
- Interim Results, Conclusions, and Recommendations:**
 - Correct SS Warning Alerts alerts have at least 15 seconds of lead time to LOWC in 83% of cases
 - 72% of Warning alerts resulted in a loss of well clear suggest alerting criteria is within suitable performance bounds
 - Even though the probability of false alert for Corrective alerts seem high, most of the encounter fall within the vertical or horizontal bounds of the well clear definition, which indicates a low severity level (most false alerts would be acceptable from a safety stand-point to overcome missed alerts)

• Research Objective:

- Evaluate the impact of UAS SAA self separation maneuvers resulting for different SAA Well Clear volumes on controller perceptions of safety and efficiency



• Results, Conclusions, and Recommendations:

- A horizontal miss distance of ~1.5 nm appears to be optimal for ATC acceptability (away from the airport vicinity)
- Horizontal miss distance of 1.5 nm is 150% larger than the TCAS resolution advisory horizontal miss distance for all airspace below Class A, and 136% larger in Class A
- 500' IFR-VFR vertical separation (with no vertical closure rate) was universally acceptable during debrief sessions
- Air traffic controllers thought the SAA integration concept as presented was viable

Well Clear Separation & ATC Interoperability Requirements for DAA MOPS

- **Research Objective:**

- Assess SAA-to-Traffic Alert and Collision Avoidance System interoperability and the impact of CNPC system delay on the execution of UAS pilot Self Separation tasks



Boeing 747



Airspace



MACS GCS Stratway+

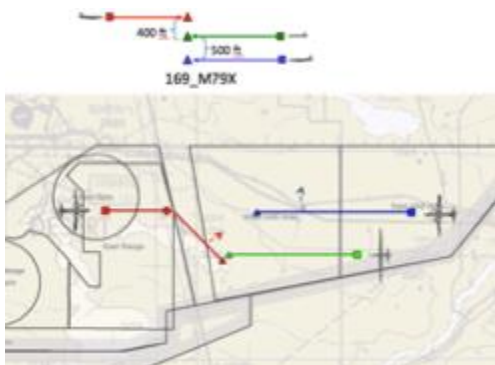
- **Interim Results, Conclusions, and Recommendations:**

- Simulation shows to maintain Well Clear and avoid almost all TCAS Resolution Advisories:
 - Above 10,000 feet with typical airliner speeds – need at least 1.5 nm Closet Point of Approach
 - Below 10,000 feet below 250 knots, need at least 1.2 nm Closet Point of Approach

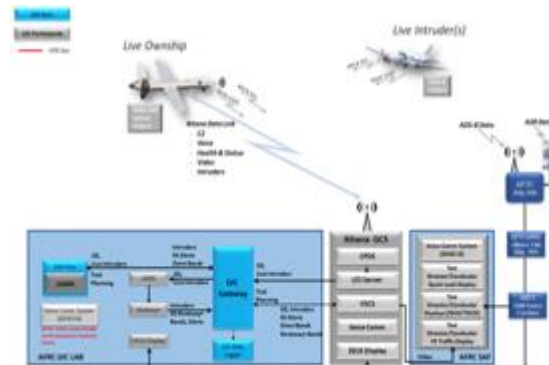
DAA – TCAS & ATC Interoperability Requirements for DAA MOPS

- Research Objectives:**

- Evaluate the performance of self separation Stratway+ algorithm using a cooperative sensor in constrained geometric/operational conditions in the presence of real winds (Min Success)
- Evaluate the performance of General Atomics Conflict Prediction and Display System vs. Stratway+ coordination of maneuver guidance and the performance of a self separation algorithm using both cooperative and non-cooperative sensors in the presence of real winds (Full Success)



FT3 Scripted Encounter Example



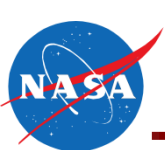
Scripted Encounter Configuration

- Interim Results, Conclusions, and Recommendations:**

- Testing successfully accomplished in July 2015
- Analysis in progress

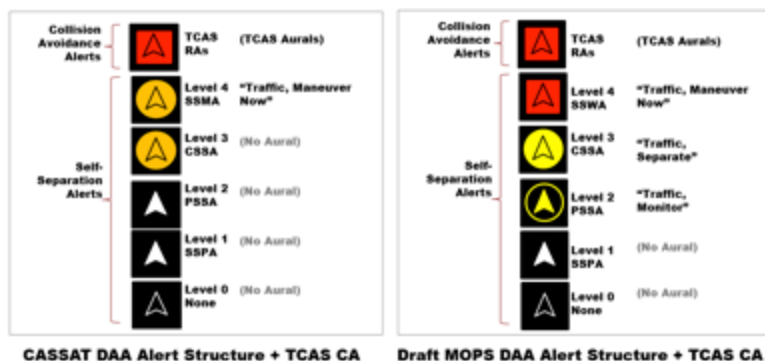
Self-Separation System Performance Requirements for DAA MOPS

Alerting Times + Collision Avoidance-Self Separation Integration Combined HITL



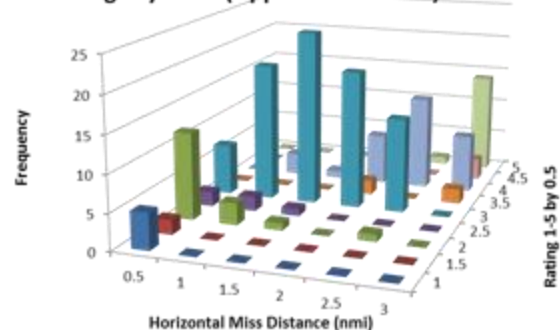
- **Research Objective:**

- Develop and evaluate a concept of integrated Collision Avoidance and Safe Separation functions that enables UAS to execute automated maneuvers in terms of acceptability to ATC, as well as investigate the range of acceptable times to alert the UAS pilot to potential loss of well-clear condition



DAA Alerting

Ratings by HMD (Opposite Direction)

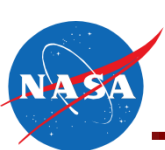


Horizontal Miss Distance Results

- **Interim Results, Conclusions, and Recommendations:**

- Testing successfully completed September 15, 2015
- Analysis in progress

Automated Self-Separation Maneuver Requirements for DAA MOPS

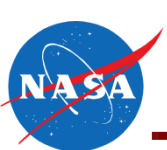


Surveillance Requirements (Medium Fidelity) (ACES Simulation)



TC-SAA Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP S.1.10] Surveillance Requirements (Low Fidelity) (ACES Simulation)	2/2014	<ul style="list-style-type: none">Analyze tradeoffs in the performance of different surveillance ranges and fields of regard using perfect sensor and unmitigated (without Autoresolver) SAA encountersExamine the impact on an aircrafts' ability to remain "Well Clear" or avoid the Near Mid-Air Collision volume without a mitigation strategy (self separation algorithm)	<ul style="list-style-type: none">Results inform:<ul style="list-style-type: none">SAA surveillance system performance requirements for multiple self-separation and collision avoidance concepts/capabilities functional requirementsThe performance characteristics of and interactions between SAA system functionsSAA algorithm development

- Briefings, Papers, or Reports
 - Surveillance Requirements (Medium Fidelity) Brief results to SC-228 planned for October 2015



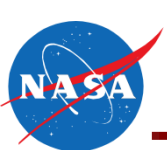
SAA Traffic Display Evaluation HITL1 (joint w/HSI Part Task Sim 4)



TC-SAA Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP S.2.10] SAA Traffic Display Evaluation HITL1 (joint w/HSI Part Task Sim 4)	2/2014	<ul style="list-style-type: none">• Evaluate integrated SAA system under perfect sensor conditions• Evaluate the pilot's ability to remain clear as a function of self separation threshold• Evaluate the pilot's acceptability of recommended Autoresolver maneuvers to avoid well-clear• Evaluate the utility of two different trial planner capabilities that aid an UAS in remaining well-clear of other traffic	<ul style="list-style-type: none">• Results:<ul style="list-style-type: none">• Inform SAA system display requirements to include trial planning capabilities• Contribute to defining performance characteristics for UAS human-automation systems• Provide estimates for the impact of UAS (pilot, traffic displays, SAA algorithm/concept/displays) operations on NAS safety over a range of UAS mission profiles• Provide estimates for number of Well Clear violations, pilot acceptability of autoresolver SAA maneuvers, pilot acceptability of alerting criteria, encounter characteristics if/when autoresolver fails to recommend a Well Clear maneuver, and Well Clear maneuver characteristics, pilot/air traffic controller negotiation times

- Briefings, Papers, or Reports

- UAS-SSI-4.1-033-001, PT4 Detect and Avoid Results Presentation, Briefing (SC-228), August 26 2014
- UAS-SSI-4.1-048-001, Pilot Evaluation of a UAS Detect-and-Avoid System's Effectiveness in Remaining Well Clear, Paper, June 2015

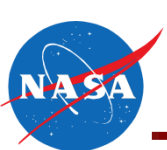


IHITL Participation & Data Collection



TC-SAA Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP S.2.20] IHITL Participation & Data Collection	6/2014	<ul style="list-style-type: none">Evaluate air traffic controller acceptability of UAS maneuvers in response to SAA advisories and pilot performance for remaining "Well Clear"	<ul style="list-style-type: none">Results inform and support understanding of:<ul style="list-style-type: none">Air traffic controller acceptability of UAS maneuvers in response to SAA advisoriesUAS pilot's performance at remaining Well Clear modeling non-cooperative sensor range, elevation, and azimuth performance as part of an SAA systemExisting air traffic control procedures and operations in the presence of a UASInteroperability between UAS pilot and air traffic controllerSensor performance on UAS pilot's ability to perform SAA functions and maintain Well ClearImpact of realistic estimate of CNPC system latency impact on UAS pilot and air traffic controller operations and performanceWell Clear as a airborne separation standard for UASAir traffic controller ability to recognize/correct a Well Clear violationUAS pilot workload

- Briefings, Papers, or Reports
 - UAS-SSI-4.1-044-001, UAS-NAS, IHITL, Pilot Detect-and-Avoid Evaluation, Briefing (SC-228), November 2014
 - UAS-SSI-4.1-045-001, Airspace Concept Evaluation System (ACES) Simulation Study, Briefing (SC-228), November 2014
 - UAS-SSI-4.1-048-001, Pilot Evaluation of a UAS Detect-and-Avoid System's Effectiveness in Remaining Well Clear, Paper, June 2015

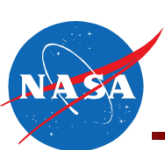


Self-Separation Risk Ratio Study



TC-SAA Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP S.2.30] Self-Separation Risk Ratio Study	4/2014	<ul style="list-style-type: none">Gather data indicating the degree to which self separation systems mitigate the probability that an encounter to the self separation threshold will proceed to a Well Clear violation (self separation Airspace Safety Threshold)	<ul style="list-style-type: none">Results:<ul style="list-style-type: none">Inform the understanding of the level of UAS safety a self-separation system could achieve in the NAS with multiple UAS mission profiles and NAS traffic estimates using perfect surveillance state information of cooperative VFR trafficProvide estimates of risk ratio as a function of self-separation threshold and Well Clear definition, number/rate of UAS-to-VFR conflicts to the self-separation threshold, number/rate of conflicts that progress to Well Clear violations, secondary encounters with other aircraft following execution of a self separation maneuver, deviation magnitude from flight plan, number of TCAS RAs generatedInform understanding of allowable tradeoffs between SAA system functionsInform UAS performance based rules for SAA equipageContribute to air traffic control operating procedures for UAS SAA systems

- Briefings, Papers, or Reports
 - UAS-SSI-4.1-037-001, Final Overview of ACES Sim for Evaluating SARP Well Clear Definitions, Briefing (SARP), August 5 2014
 - UAS-SSI-4.1-039-001, ACES Mitigated Results Supporting Selection of SARP Well-Clear Definition Maneuver Initiation Point MIP, Briefing (SC-228), August 7 2014
 - UAS-SSI-4.1-040-001, ACES Unmitigated and some Mitigated Results Supporting Selection of SARP Well Clear Definition, Briefing (SC-228), August 5 2014
 - UAS-SSI-4.1-042-001, Encounter Rate Simulation Study with UAS Missions, Briefing, September 2014
 - UAS-SSI-4.1-060-001, Airspace Safety Threshold Study- NAS-wide Encounter Rate Evaluation using Historical Radar Data and ACES, Briefing, May 2015

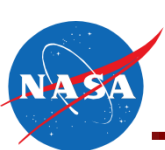


SSI-ARC FT3 Participation & Data Collection



TC-SAA Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP S.2.40] FT3 Participation & Data Collection	6/2015	<ul style="list-style-type: none">Gather data on the performance of a SAA concept with flight representative trajectory uncertainties, control and non-payload communication system characteristics, vehicle dynamics, and SAA sensors in order to improve and calibrate simulation models	<ul style="list-style-type: none">Results used to calibrate models with flight test data (Communication system models, UAS performance models, sensor models, trajectory performance models)Results inform DAA MOPS

- Briefings, Papers, or Reports
 - FT3 Participation & Data Collection SSI ARC FT3 brief results to SC-228 planned for January 2016
 - FT3 Participation & Data Collection SSI ARC FT3 report/paper planned for January 2016

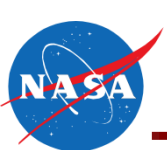


SSI-ARC FT4 Participation & Data Collection



TC-SAA Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP S.2.50] FT4 Participation & Data Collection	2/2016	<ul style="list-style-type: none">Determine the performance of a SAA conceptGather data for additional validation of simulation models and results with flight representative trajectory uncertainties, control and non-payload communication system characteristics, vehicle dynamics, and SAA sensors	<ul style="list-style-type: none">Results inform:<ul style="list-style-type: none">DAA MOPSAccuracy of ACES simulation results

- Briefings, Papers, or Reports
 - FT4 Participation & Data Collection SSI ARC FT4 brief results to SC-228 planned for June 2016
 - FT4 Participation & Data Collection SSI ARC FT4 report/paper planned for June 2016

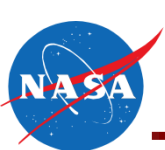


SAA Traffic Display Evaluation HITL2 (joint w/HSI Part Task Sim 5)



TC-SAA Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP S.2.60] SAA Traffic Display Evaluation HITL2 (joint w/HSI Part Task Sim 5)	2/2015	<ul style="list-style-type: none">Evaluate the pilot's ability to remain clear of other traffic with different sensor range and field of regard limitations, and sensor uncertainties	<ul style="list-style-type: none">Results inform:<ul style="list-style-type: none">Pilot's acceptability of Autoresolver resolutions and trial planning capabilityAnd support the development of SAA system requirements and performance standards (MOPS)

- Briefings, Papers, or Reports
 - SAA Traffic Display Evaluation HITL2 brief results to SC-228 planned for May 2015
 - SAA Traffic Display Evaluation HITL2 Results Simulation report planned for September 2015

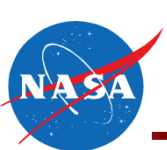


Effect of SAA Maneuvers with Procedures (ACES Simulation)



TC-SAA Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP S.2.70] Effect of SAA Maneuvers with Procedures (ACES Simulation)	4/2015	<ul style="list-style-type: none">Gather data indicating the degree to which Self Separation systems mitigate the probability that an encounter to the Self Separation threshold will proceed to a well clear violation (Self Separation Airspace Safety Threshold), using higher fidelity models of sensor uncertainties, communications latencies and pilot-controller interactions	<ul style="list-style-type: none">Results inform:<ul style="list-style-type: none">risk ratio for self-separation systems with imperfect surveillance state information and realistic pilot-controller negotiation times against cooperative and non-cooperative VFR trafficAnd support the development of SAA system requirements and performance standards (MOPS)

- Briefings, Papers, or Reports
 - UAS-SSI-4.1-049-001, UAS DAA SS Risk Ratio Study AKA Effect of SAA Maneuvers with Procedures Experiment Design Review - Not for Public Release, Brief, September 2014
 - ACES Simulation Report planned for December 2015

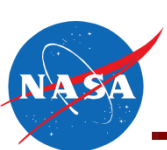


Comprehensive Evaluation of Airspace Risk Threshold (ACES Simulation)



TC-SAA Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP S.2.80] Comprehensive Evaluation of Airspace Risk Threshold (ACES Simulation)	2/2016	<ul style="list-style-type: none">Gather data indicating the degree to which Self Separation systems mitigate the probability that an encounter to the Self Separation threshold will proceed to a well clear violation, using higher fidelity models of sensor uncertainties, communications latencies and pilot-controller interactions that have been validated by flight test data	<ul style="list-style-type: none">Results inform:<ul style="list-style-type: none">Fast-time simulation results, validated by flight tests, indicating which combinations of SAA system parameters would allow UAS operations to meet the airspace risk thresholdAutoResolver (as a proxy for pilot-in-the-loop self-separation system) ability to mitigate well clear violations relative to the SST encounter rateThe combinations of SAA system parameters (e.g. allowable latency, surveillance range) that allows UAS operations to meet the airspace risk thresholdand support the development of SAA system requirements and performance standards (MOPS)

- Briefings, Papers, or Reports
 - Comprehensive Evaluation of Airspace Risk Threshold SSI ARC Brief results to SC-228 planned for July 2016
 - ACES Simulation Report planned for August 2016

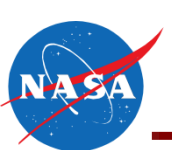


Well Clear Metric and Definition Study



TC-SAA Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP S.3.10] Well Clear Metric and Definition Study	4/2014	<ul style="list-style-type: none">Gather data and develop recommendations for a quantified definition of “Well Clear” using cooperative Visual Flight Rule traffic that meets target level of safety requirements and NAS-interoperability considerations	<ul style="list-style-type: none">Results:<ul style="list-style-type: none">Inform the development of a quantified Well Clear definition and SAA concept with multiple UAS mission profiles and NAS traffic estimates using perfect surveillance state information of cooperative VFR trafficContribute to the definition of Well Clear time and/or distance dimensionsGenerate Well Clear maneuver resolution characteristics for UAS and cooperative VFR traffic for multiple definitions of Well ClearProvide estimates for risk ratio as a function of self-separation threshold and Well Clear definition, number/rate of Well Clear violation, number/rate of NMAC, number of generated TCAS RAs, number/rate of UAS-to-VFR traffic conflicts to the self-separation threshold

- Briefings, Papers, or Reports
 - UAS-SSI-4.1-026-001, Investigating Effects of Well Clear Definitions on UAS SAA Operations Slides, Briefing, Plan, May 2014
 - UAS-SSI-4.1-046-001, Investigating the Impacts of a Separation Standard for UAS Enroute and Transition Airspace, Paper, November 2014



DAA Self-Separation Alerting Methods, Performance, and Robustness Study (ACES Simulation)

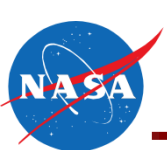


TC-SAA Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP S.3.30] DAA Self-Separation Alerting Methods, Performance, and Robustness Study (ACES Simulation)	3/2015 (Phase 1) 7/2015 (Phase 2)	<ul style="list-style-type: none">Gather data to support development of alerting logic, methods, and performance requirements using cooperative and non-cooperative VFR traffic and the SC-228 definition of Well Clear considering target level of safety and NAS-interoperability	<ul style="list-style-type: none">Results inform:<ul style="list-style-type: none">Fast-time simulation results for a SAA concept incorporating well clear alerting logic with perfect surveillance state information against cooperative and non-cooperative VFR trafficAlerting logic methods and performanceSelection of a particular SAA concept of operations using the fast time simulation results

- Briefings, Papers, or Reports
 - UAS-SSI-4.1-050-001, UAS DAA Alerting Studies and ACES Fast Time Simulation - Not for Public Release, Brief, February 2015
 - UAS-SSI-4.1-061-001, Analysis of Baseline PT5 Alerting Scheme in Fast-Time Simulations without DAA Mitigation, Briefing, May 2015
 - Phase 2 - Document results in final report/briefing planned for December 2015

TC-SAA Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP S.4.20] Collision Avoidance/Self Separation Algorithm Maneuvers vs. UA Performance Assessment	2/2016	<ul style="list-style-type: none"> Generate performance data for the trade-off space between UAS and DAA algorithm performance 	<ul style="list-style-type: none"> Results inform: <ul style="list-style-type: none"> Maneuver time requirements for a spanning set of aircraft performance models over a broad range of encounters for selected algorithms DAA requirements DAA MOPS

- Briefings, Papers, or Reports
 - Collision Avoidance/Self Separation Algorithm Maneuvers vs. UA Performance Assessment Preliminary Results for Stakeholders Available July2016
 - Collision Avoidance/Self Separation Algorithm Maneuvers vs. UA Performance Assessment Results Paper planned for August 2016



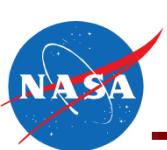
UAS CAS1 HITL



TC-SAA Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP S.5.10] UAS CAS1 HITL	1/2014	<ul style="list-style-type: none">Evaluate the impact of UAS SAA self separation maneuvers resulting for different SAA Well Clear volumes on controller perceptions of safety and efficiency	<ul style="list-style-type: none">Results inform:<ul style="list-style-type: none">Understanding of air traffic controller operational acceptability of UAS Stratway+ self-separation concept/capabilityUnderstanding of air traffic controller operational acceptability of quantifying the definition of Well ClearUnderstanding of air traffic controller workload in the presence of a UAS with Stratway+ self-separation concept/capability operating in the NASUnderstanding of interoperability of UAS Stratway+ self-separation concept/capability and TCAS II

- Briefings, Papers, or Reports

- UAS-SSI-4.1-016-001, UAS Controller Acceptability Study 1 (UAS-CAS1) Test Plan, November 2013
- UAS-SSI-4.1-019-001, UAS-CAS1 FER Slides, Briefing, November 2013
- UAS-SSI-4.1-021-001, UAS CAS1, Briefing (AUVSI), May 2014
- UAS-SSI-4.1-031-001, UAS-CAS1, Briefing (SC-228), May 2014
- UAS-SSI-4.1-051-001, UAS in the NAS Air Traffic Controller Acceptability Study - 1 the Effects of Horizontal Miss Distances on Simulated UAS and Manned Aircraft Encounters, Briefing, May 2015
- UAS-SSI-4.1-052-001, UAS in the NAS Air Traffic Controller Acceptability Study - 1 the Effects of Horizontal Miss Distances on Simulated UAS and Manned Aircraft Encounters, Paper, May 2015



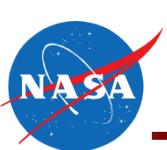
SSI-LaRC Support & Participation in IHITL



TC-SAA Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP S.5.20] Langley Support & Participation in IHITL	6/2014	<ul style="list-style-type: none"> Assess SAA-to-Traffic Alert and Collision Avoidance System interoperability and the impact of CNPC system delay on the execution of UAS pilot self separation tasks 	<ul style="list-style-type: none"> Results inform and support understanding of: <ul style="list-style-type: none"> Air traffic controller acceptability of UAS maneuvers in response to SAA maneuvers Compatibility of the Stratway+ SAA concept (and Well Clear criteria implementation) with existing TCAS II equipped aircraft Impact of CNPC system latencies on UAS pilot and air traffic controller operations and performance Impact of wind direction and velocity on UAS pilot and air traffic controller operations and performance Interoperability of SAA concept with TCAS equipped aircraft Collision Avoidance Volumes

- Briefings, Papers, or Reports

- UAS-SSI-4.1-022-001, UAS Controller Acceptability Study 2 (UAS-CAS2) and IHITL Test Plan, May 2014
- UAS-SSI-4.1-023-001, UAS-CAS2 IHITL (PER-FER), Briefing, May 2014
- UAS-SSI-4.1-024-001, IHITL Experiment Plan-Controller Subjects (aka Configuration 1, test setup 1), Briefing, May 2014
- UAS-SSI-4.1-043-001, Completed, Ongoing and Upcoming Experiments iHITL-B747-TCAS and IHITL-CAS2 Overview and Results, Briefing (SC-228), November 2014
- UAS-SSI-4.1-053-001, UAS Air Traffic Controller Acceptability Study 2 - Effects of Communications Delays and Winds in Simulation, Paper, May 2015

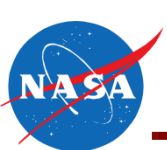


SSI LaRC Support & Participation in FT3



TC-SAA Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP S.5.40] SSI LaRC Support & Participation in FT3	6/2015	<ul style="list-style-type: none">Evaluate the performance of self separation Stratway+ algorithm using a cooperative sensor in constrained geometric/operational conditions in the presence of real winds (Min Success)Evaluate the performance of General Atomics Conflict Prediction and Display System vs. Stratway+ coordination of maneuver guidance and the performance of a self separation algorithm using both cooperative and non-cooperative sensors in the presence of real winds (Full Success)	<ul style="list-style-type: none">Results inform:<ul style="list-style-type: none">Performance of self separation-Stratway+ algorithm using a cooperative sensor in constrained geometric/operational conditions in the presence of real winds (min success).Performance of CPDS vs. Stratway+ coordination of maneuver guidance, and performance of a self separation algorithm (CPDS on Ikhana) using both cooperative and non-cooperative sensors, in the presence of real winds (full success)DAA requirementsDAA MOPS

- Briefings, Papers, or Reports
 - SSI LaRC Support & Participation in FT3 Brief Results to SC-228 planned for January 2016
 - SSI LaRC FT3 report/paper planned for February 2016



SSI LaRC Support & Participation in FT4



TC-SAA Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP S.5.50] SSI LaRC Support & Participation in FT4	2/2016	<ul style="list-style-type: none">Evaluate the performance of self separation Stratway+ algorithm in constrained geometric/operational conditions in the presence of real winds for both cooperative and non-cooperative targets utilizing a fast (~250 knots) surrogate UAS with a full DAA sensor suite and fusion/tracker capability (min success)Evaluate the performance of a self separation algorithm in constrained geometric/operational conditions in the presence of real winds and a suite of sensors for both cooperative and non-cooperative targets utilizing a live UAS as part of the flight scenarios (full success)	<ul style="list-style-type: none">Results inform:<ul style="list-style-type: none">SAA system performance with fast (~250 knots) surrogate UAS equipped with CNPC, a full suite of sensors for cooperative and non-cooperative targets with guidance provided by Stratway+/RGCS (min success)SAA system performance from Ikhana (or alternate, equivalent UAS capability) equipped with CNPC, a full suite of sensors for cooperative and non-cooperative targets with guidance provided by CPDS (or equivalent DAA algorithm capability such as Stratway+) (full success)DAA requirementsDAA MOPS

- Briefings, Papers, or Reports

- SSI LaRC Support & Participation in FT4 Brief Results to SC-228 planned for July 2016
- SSI LaRC FT4 report/paper planned for August 2016



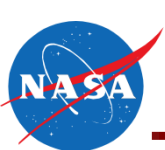
Alerting Times + Collision Avoidance-Self Separation Integration Combined HITL



TC-SAA Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP S.5.60] Alerting Times + Collision Avoidance-Self Separation Integration Combined HITL	5/2015	<ul style="list-style-type: none"> Develop and evaluate a concept of integrated Collision Avoidance and Safe Separation functions that enables UAS to execute automated maneuvers in terms of acceptability to ATC, as well as investigate the range of acceptable times to alert the UAS pilot to potential loss of well-clear condition 	<ul style="list-style-type: none"> Results inform: <ul style="list-style-type: none"> Declaration times: what are excessive, leading to nuisance alerts for controllers and UA pilots and what times are too short and provide insufficient time to query/negotiate maneuvers with ATC and execute them before triggering TCAS RAs. The feasibility of the integration of self separation and collision avoidance functions as part of a complete SAA capability

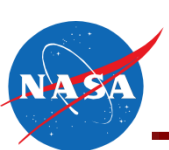
- Briefings, Papers, or Reports
 - UAS-SSI-4.1-059-001, UAS CAS3 CASSAT PER/FER, Briefing Plan, March 2015
 - Alerting Times + Collision Avoidance-Self Separation Integration Combined HITL Brief results to SC-228 planned for February 2016
 - HITL Results Paper planned for March 2016

GA-FAA (SAA Initial Flight Tests) Flight Test Participation w/IT&E



TC-SAA Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP S.6.10] SAA Initial Flight Test Participation w/IT&E	11/2014	<ul style="list-style-type: none"> Perform collaborative flight tests and demonstrations to evaluate, validate and refine simulation-tested SAA concepts in an actual flight environment with prototype airborne sensors for non-cooperative intruders in addition to ADS-B and TCAS II, as well as prototype ground station information displays 	<ul style="list-style-type: none"> Results: <ul style="list-style-type: none"> Performance data from flight test will continue to support the development of the Stratway+ SAA concept by verifying Stratway+ self-separation algorithm performance in a flight test environment Provide risk reduction for the IT&E subproject live, virtual, constructive distributed test environment Inform performance Self Separation requirements and standards Inform the development of surveillance system architecture requirements

- Briefings, Papers, or Reports
 - GA-FAA (SAA Initial Flight Tests) Flight Test Participation w/IT&E Technical Conference Paper planned for October 2015

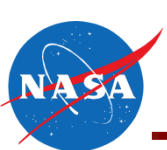


Sensor Model Stress Testing & Sensitivity Analysis HITL

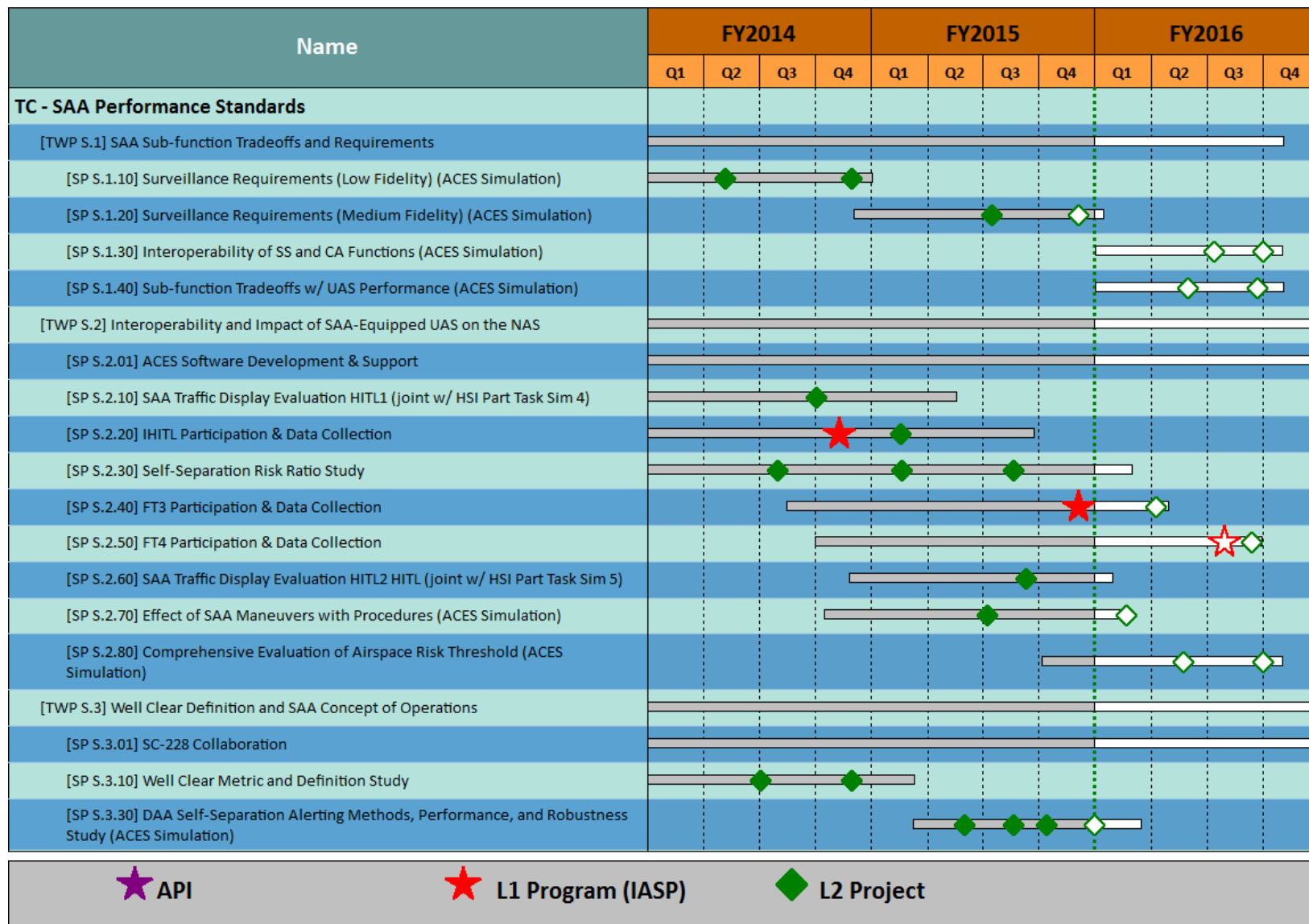


TC-SAA Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP S.7.10] Sensor Model Stress Testing & Sensitivity Analysis HITL	2/2016	<ul style="list-style-type: none">Evaluation of the NASA developed Stratway+ SAA algorithm and pilot interface subject to various types and levels of uncertainty and sensor models errors in a human-in-the-loop simulation	<ul style="list-style-type: none">Results inform:<ul style="list-style-type: none">The performance of an integrated SAA capability (self separation and collision avoidance) in a HITL experiment with modeled sensor uncertainties and realistic traffic scenariosDAA requirementsDAA MOPS

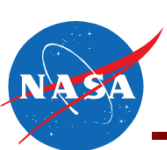
- Briefings, Papers, or Reports
 - Sensor Model Stress Testing & Sensitivity Analysis HITL Preliminary Results for Stakeholders Available July 2016
 - HITL Results Paper planned for August 2016



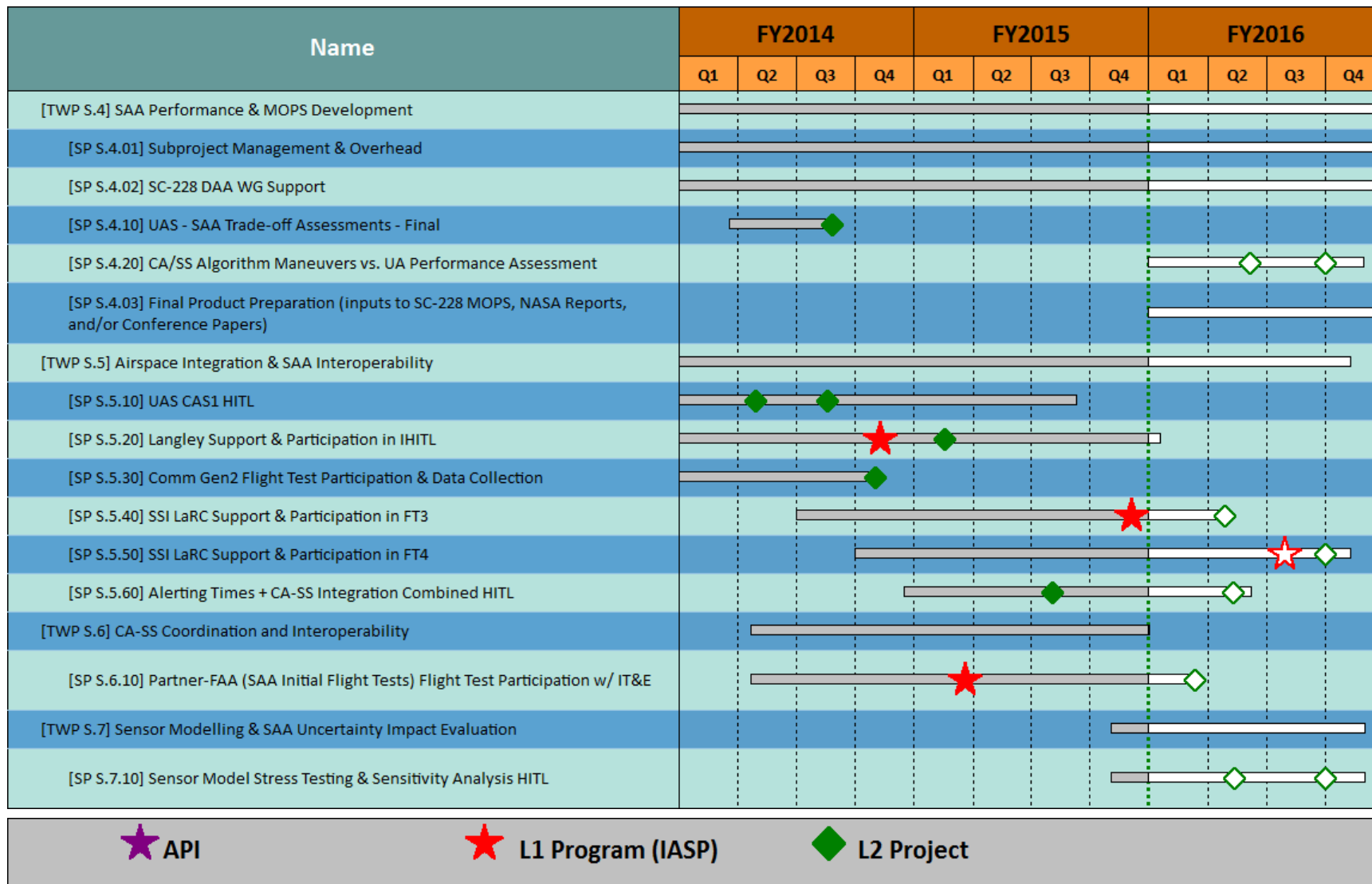
TC – SAA (1 of 2)



Green Status Line Date 9/30/15



TC – SAA (2 of 2)

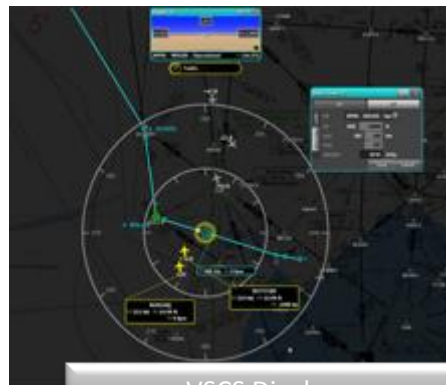


Green Status Line Date 9/30/15

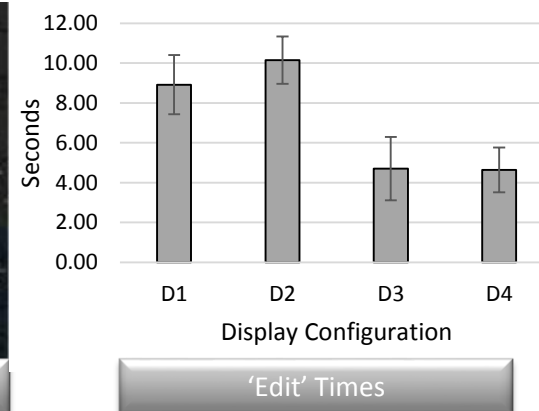
- **Research Objective:**
 - Evaluate an instantiation of the prototype GCS in relevant environment



MACS GCS Display



VSCS Display



- **Interim Results, Conclusions, and Recommendations:**
 - Integration of guidance and auto pilot in the *auto-resolver* and *auto resolver + vector planner* conditions led to significantly faster pilot 'edits'
 - No other significant differences in pilot response times
 - Rorie, R. C., & Fern, L. (2015). The impact of integrated maneuver guidance information on UAS pilots performing the detect and avoid task. *Proceedings of Human Factors and Ergonomics Society*, Los Angeles, CA, Oct 26-30

- **Research Objective:**

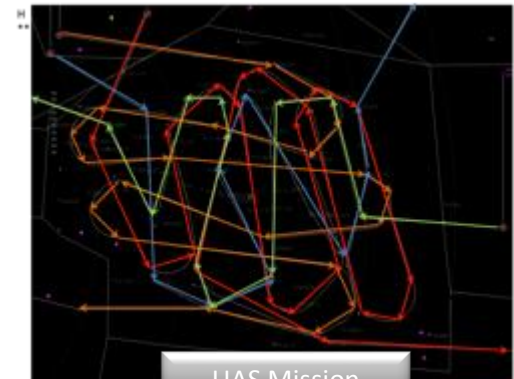
- Investigate the effects of number of UAS per sector and types of UAS on GCS information requirements



Air Traffic Controller



Airspace



UAS Mission

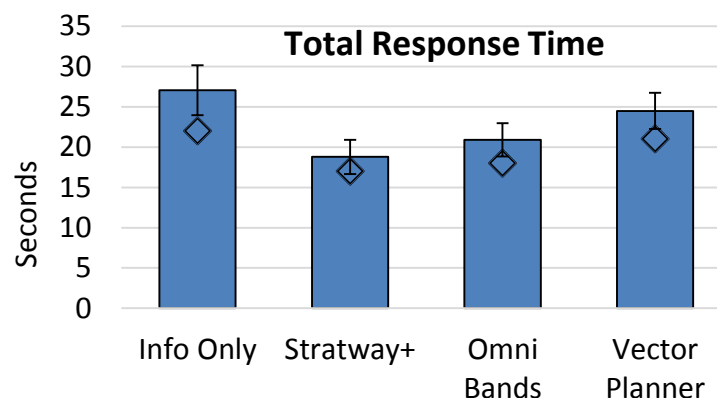
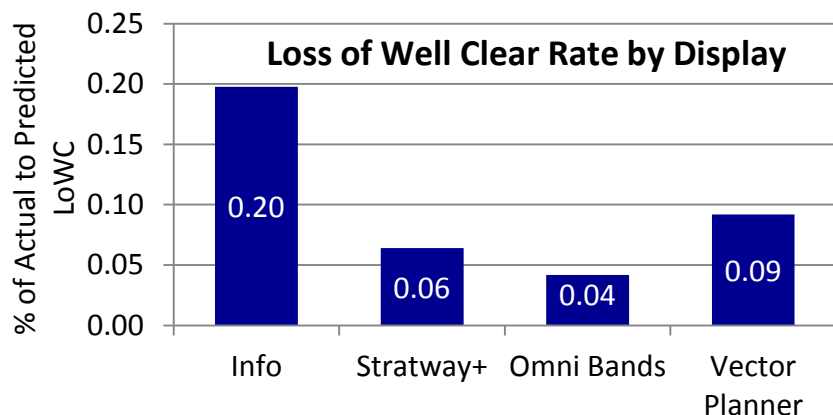
- **Results, Conclusions, and Recommendations:**

- No significant effect on number of UAS on loss of separation
- In terms of efficiency, the time it took aircraft to travel through the sector increased with more UAS and increased with mixed and fast UAS, when multiple UAS were present
- Handoff accept time decreased with increasing number of UAS, due to the reduction in conventional aircraft entering the sector and varied as a function of the combination of number of UAS and the speed
- The presence of additional UAS negatively impacted Air Traffic Controller performance

GCS Information Guidelines/Requirements for DAA and C2 MOPS

- **Research Objective:**

- Evaluate various proposed informational and directive SAA displays to determine the basic information requirements and advantages of advanced pilot guidance



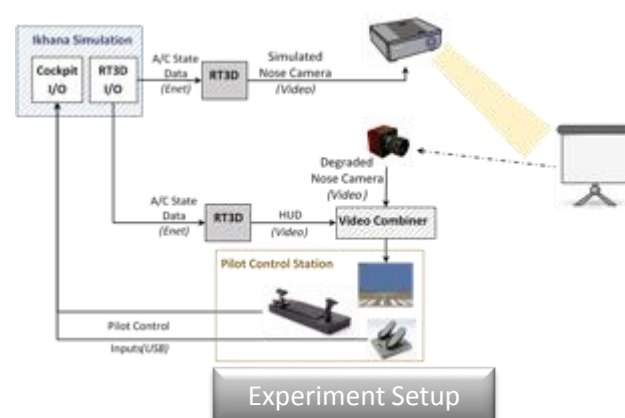
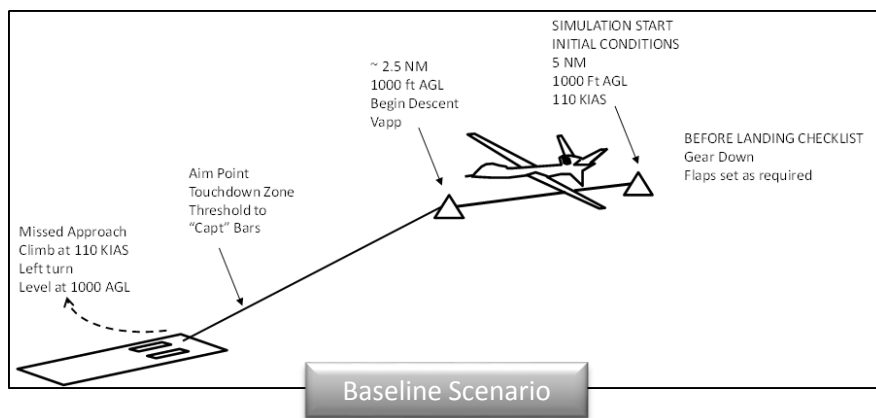
- **Interim Results, Conclusions, and Recommendations:**

- Suggestive guidance in the form of banding resulted in **safer** and **more timely** maneuvers away from conflicts
 - Fewer overall number of LoWC for both banding displays
 - Faster overall response times for both banding displays
- Rorie, R. C., Fern, L., & Shively, J. (2016). The impact of suggestive maneuver guidance on UAS pilots performing the detect and avoid function. *Proceedings of AIAA Science and Technology Forum and Exposition 2016*, San Diego, CA, Jan 4-8

GCS Display Minimum Information Guidelines/Requirements for DAA and C2 MOPS

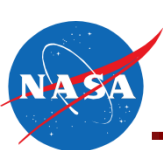
- Research Objectives:**

- Evaluate nose camera video display requirements for manual takeoff and landing
- Determine the minimum C2 bandwidth that still enables the safe execution of the takeoff and landing tasks



- Results, Conclusions, and Recommendations:**

- Preliminary qualitative results obtained with three pilot participants indicated that the degraded video resolution and frame rates affected their ability to fly a safe approach in a number of ways
- Overall the pilots stated that the degradation in the resolution was manageable, whereas they felt "dangerous" with the degradation in frame rate
- Internal Project Paper: *Required Bandwidth for GCS Display(s) Supporting UAS Landing*

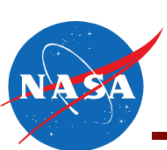


HSI IHITL Participation & Data Collection



TC-HSI Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP H.1.10] HSI IHITL Participation & Data Collection	5/2014	<ul style="list-style-type: none">Evaluate an instantiation of the prototype GCS in relevant environment.	<ul style="list-style-type: none">Results inform the understanding of:<ul style="list-style-type: none">Acceptability to the air traffic controller of UA maneuvers in response to SAA advisories and air traffic controller clearancesAcceptability to the air traffic controller of the procedures for negotiation with UAS pilots to conduct maneuvers to remain Well ClearThe performance of the UAS pilot to control/maneuver the UA in response to SAA alerts, advisories, and situational awareness information displayed to the UAS pilotAcceptability to the UAS pilot of the procedures for negotiation with air traffic controllers to conduct maneuvers to remain Well Clear

- Briefings, Papers, or Reports
 - UAS-HSI-4.2-025-001, IHITL: DAA Display Evaluation Preliminary Results, Briefing (SC-228), November 2014
 - Rorie, R. C., & Fern, L. (2015). The impact of integrated maneuver guidance information on UAS pilots performing the detect and avoid task. *Proceedings of Human Factors and Ergonomics Society*, Los Angeles, CA, Oct 26-30, to be published
 - IHITL results report/paper planned for October 2015

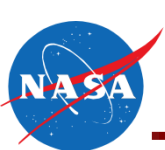


Measured Response Simulation C



TC-HSI Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP H.1.20] Measured Response Simulation C	10/2013	<ul style="list-style-type: none">Investigate the effects of number of UAS per sector and types of UAS on GCS information requirements	<ul style="list-style-type: none">Results inform understanding of ground control station automation levels and the number of UAS per NAS sector and types of UAS in the sector

- Briefings, Papers, or Reports
 - UAS-HSI-4.2-013-001, Measured Response Simulation C-Preliminary Data Analyses, Briefing, Undated
 - UAS-HSI-4.2-019-001, UAS Response to Air traffic Control Clearances- Measured Responses, Paper, Undated
 - UAS-HSI-4.2-020-001, Measured Response For UAS-NAS, Paper, Undated
 - UAS-HSI-4.2-021-001, UAS Measured Response: The Effect of GCS Control Mode Interfaces on Pilot Ability to Comply with ATC Clearances, Paper, Undated
 - UAS-HSI-4.2-023-001, Measured Response The effect of GCS Control Mode Interfaces on Pilot Ability to Comply with ATC Clearances, Briefing (HFES), 2014
 - UAS-HSI-4.2-025-001, Air Traffic Controller Performance and Acceptability of Multiple UAS in a Simulated NAS Environment, Paper, Undated
 - UAS-HSI-4.2-026-001, Air Traffic Controller Performance and Acceptability of Multiple UAS in a Simulated NAS Environment, Paper, July 2014

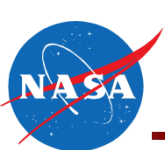


Part-task Simulation 4: SAA Pilot Guidance



TC-HSI Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP H.1.40] Part-task Simulation 4: SAA Pilot Guidance	2/2014	<ul style="list-style-type: none">Evaluate efficacy of minimum information SAA displays, potential improvements for advanced information features and pilot guidance, and integrated vs. stand-alone GCS SAA displays	<ul style="list-style-type: none">Results inform ground control system display requirements associated with display class (integrated, stand alone), level of information (basic, advanced), and self-separation alerting threshold.

- Briefings, Papers, or Reports
 - UAS-HSI-4.2-022-001, PT4: DAA Display Evaluation-Prelim Results, Briefing (SC-228), August 2014
 - UAS-HSI-4.2-033-001, An Evaluation of DAA Displays for Unmanned Aircraft Systems The Effect of Information Level and Display Location on Pilot Performance, May 2015

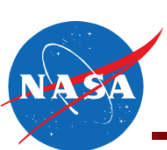


Part-task Simulation 5: SAA Pilot Guidance Follow-on



TC-HSI Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP H.1.70] Part-task Simulation 5: SAA Pilot Guidance Follow-on	2/2015	<ul style="list-style-type: none">Evaluate various proposed informational and directive SAA displays to determine the basic information requirements and advantages of advanced pilot guidance	<ul style="list-style-type: none">Results inform:<ul style="list-style-type: none">DAA display requirementsClasses of displays ability to meet proposed DAA GCS display requirements.Selection of SAA display for the prototype research GCS for use in subsequent simulations and flight tests

- Briefings, Papers, or Reports
 - Rorie, R. C., Fern, L., & Shively, J. (2016). The impact of suggestive maneuver guidance on UAS pilots performing the detect and avoid function. *Proceedings of AIAA Science and Technology Forum and Exposition 2016*, San Diego, CA, January 2015
 - UAS-HSI-4.2-034-001, UAS-NAS Part Task 5 DAA Display Evaluation Primary Results, May 2015
 - UAS-HSI-4.2-032-001 , PT5 DAA Display Evaluation Overview III, June 2015
 - NAS Compliant Ground Station Part-task Simulation 5 report planned for January 2016

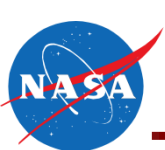


Part Task Simulation 6



TC-HSI Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP H.1.80] Full-Mission Simulation 2	11/2015	<ul style="list-style-type: none">• Evaluate boundary between self separation and automatic collision avoidance mode• Demonstrate operation of an instantiation of a GCS illustrating one manner of compliance with GCS guidelines	<ul style="list-style-type: none">• Results inform:<ul style="list-style-type: none">• Initial recommendations for allowable levels of automation• Demonstrate a robust system that provides:<ul style="list-style-type: none">• Self-separation• Contingency management• Tolerable Pilot workload• High Pilot Situation Awareness• No adverse effects on ATM• Development of a prototype GCS that will instantiate one manner of compliance with proposed GCS guidelines and serve as GCS for the integrated events

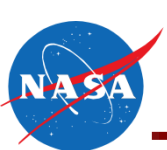
- Briefings, Papers, or Reports
 - Full-Mission 2 Briefing to SC-228 planned for March 2016
 - NAS Compliant Ground Station Full-mission Simulation 2 report planned April 2016



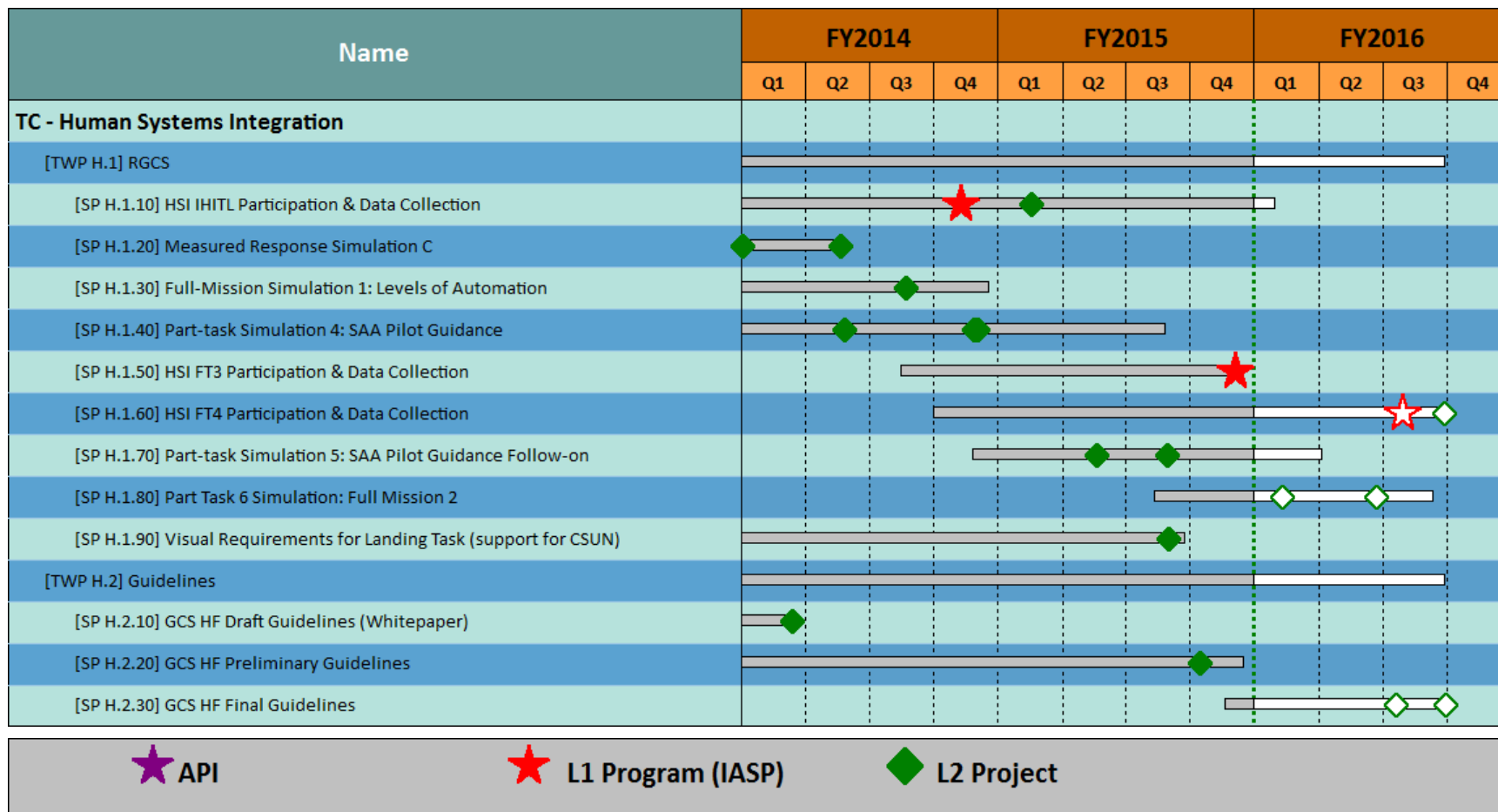
Visual Requirements for Landing Task (support for CSUN)



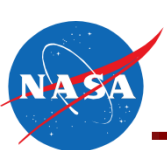
TC-HSI Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP H.1.90] Visual Requirements for Landing Task (support for CSUN)	10/2013	<ul style="list-style-type: none">Evaluate nose camera video display requirements for manual takeoff and landing, and determine the minimum C2 bandwidth that still enables the safe execution of the takeoff and landing tasks	<ul style="list-style-type: none">Results inform:<ul style="list-style-type: none">Requirements for visual displays for landing (e.g., resolution, frame rate, color)CNPC system bandwidth requirements to support acceptable visual displays for landing



TC - HSI



Green Status Line Date 9/30/15

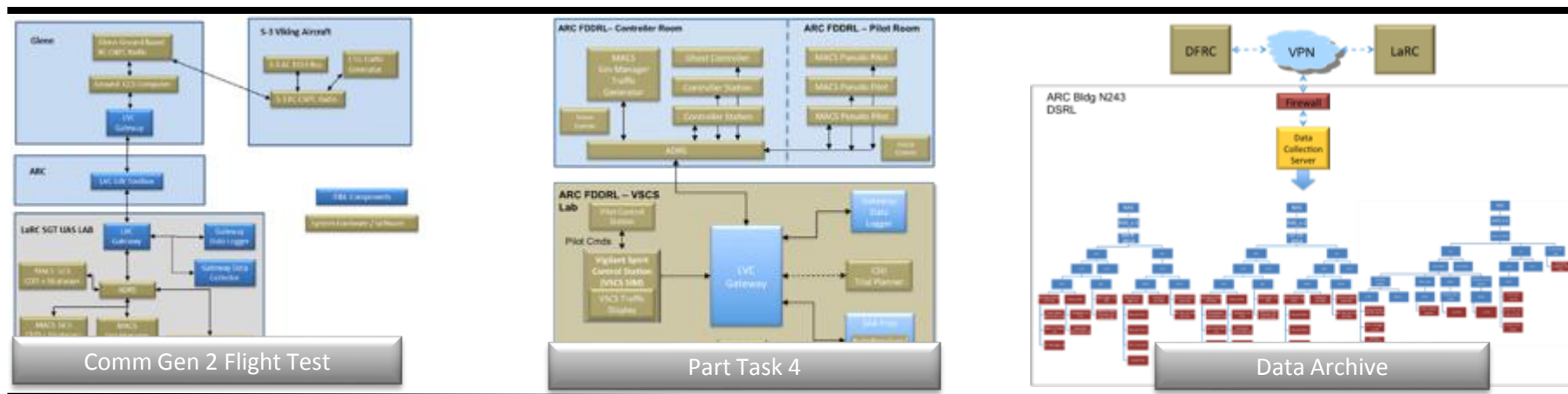


Sim and Demo Planning Support & Leave Behind Capability



- **Research Objective:**

- Develop and maintain a relevant test environment to support sub-project research simulations, identify and document the LVC interfaces, and reduce risk for the integrated events by implementing the prototype infrastructure



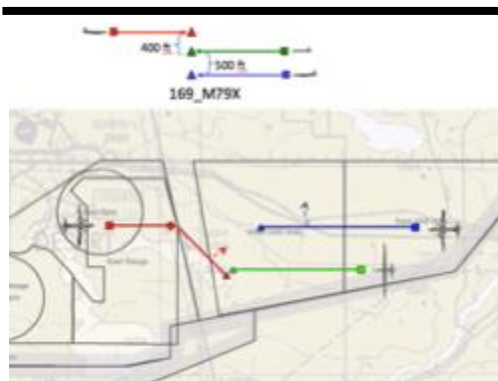
- **Results, Conclusions, and Recommendations:**

- LVC test environment development
 - Developed scenarios and integrated test components for Part Task 4, reducing IHITL implementation risk
 - Enabled real-time remote viewing of flight data via distributed test environment for SSI Subproject portion of Communication Gen 2 flight test
 - Supported center connections to GRC and LaRC
- Designed and developed a data archive scheme for integrated events
 - Proposing expansion of archive for all Project events

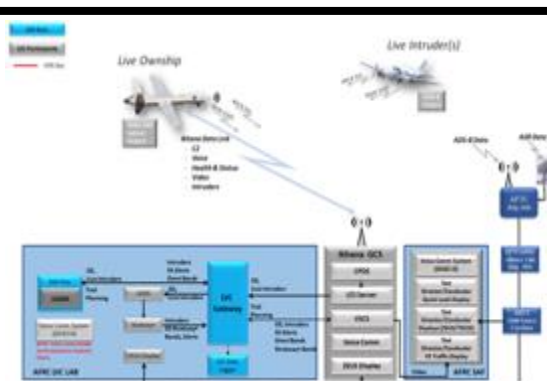
Test Environment and Support for Draft DAA and C2 MOPS

Research Objectives:

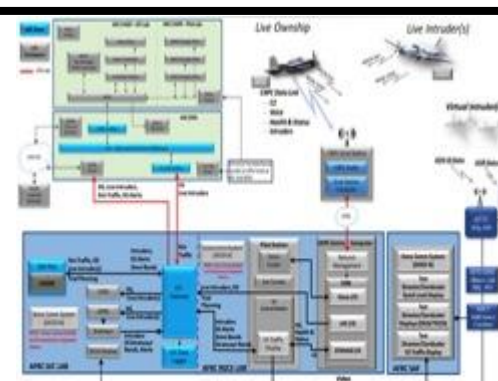
- Conduct Flight Test Series 3 integrating the latest SSI algorithms, Control and Non-Payload Communication System prototype, and HSI displays using the Live, Virtual, Constructive test environment
- Document the performance of the test infrastructure in meeting the flight test requirements



FT3 Scripted Encounter Example



Scripted Encounter Configuration

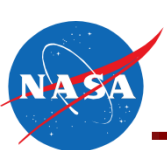


Full Mission Configuration

Results, Conclusions, and Recommendations:

- Flight test divided into scripted encounters and full mission configurations
- Scripted encounters finished successfully with 11 flights/208 test points: conducted June 2015 to July 2015
 - Ikhana as ownship, single and multiple simultaneous intruders
 - Due Regard Radar, ADS-B, and TCAS/Mode S sensors
 - Data was successfully collected for each test point and archived at NASA ARC for researcher access
- Full mission finished after 3 flights: conducted August 2015
 - Distributed live aircraft at AFRC and virtual traffic from ARC
 - Surrogate aircraft command latency and performance issues
- Required data provided to researchers on schedule

Test Environment for V&V of DAA and C2 MOPS

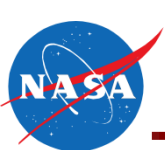


Sim and Demo Planning Support



TC-ITE Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP T.1.10] Sim and Demo Planning Support	10/2013	• Not applicable	• Not applicable
[SP T.1.20] Submit LVC Leave behind document	10/2013	• Not Applicable	• Not Applicable

- Briefings, Papers, or Reports
 - SP T.1.10, None Planned
 - SP T.1.20, LVC Leave Behind Capabilities Report, Planned for September 2016

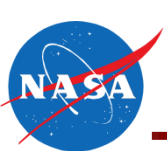


IHITL Relevant Environment Analysis



TC-ITE Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP T.2.60] Integrated Human- in-the-Loop Relevant Environment Analysis	2/2015	<ul style="list-style-type: none">Evaluate the performance of the simulation infrastructure to emulate the intended Integrated Human-in-the-Loop operational system and provide a realistic environment for air traffic controller simulation subjects.	<ul style="list-style-type: none">A realistic environment contributes useful data to SC-228 MOPS development

- Briefings, Papers, or Reports
 - UAS-ITE-5.0-008-001, IHITL Test Environment Report

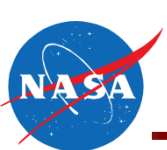


SAA Initial Flight Tests Execution



TC-ITE Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP T.3.40] SAA Initial Flight Test Execution	11/2014	<ul style="list-style-type: none">Conduct SAA Initial Flight Test using the Live, Virtual, Constructive test environment and document the performance of the test infrastructure in meeting the flight test requirements	<ul style="list-style-type: none">Results inform acceptability of the live, virtual, constructive distributed test environment as a realistic test environment for use in verifying and validating MOPS

- Briefings, Papers, or Reports



FT3 Execution



TC-ITE Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP T.4.50] FT3 Execution	6/2015	<ul style="list-style-type: none">Conduct Flight Test Series 3 integrating the latest SSI algorithms, Control and Non-Payload Communication System prototype, and HSI displays using the Live, Virtual, Constructive test environment and document the performance of the test infrastructure in meeting the flight test requirements	<ul style="list-style-type: none">Results inform acceptability of the live, virtual, constructive distributed test environment as a realistic test environment for use in verifying and validating MOPS

- Briefings, Papers, or Reports
 - Integrated Flight Test 3 Flight Test Report, Planned October 2015

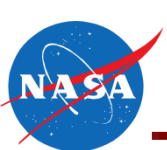


FT4 Execution

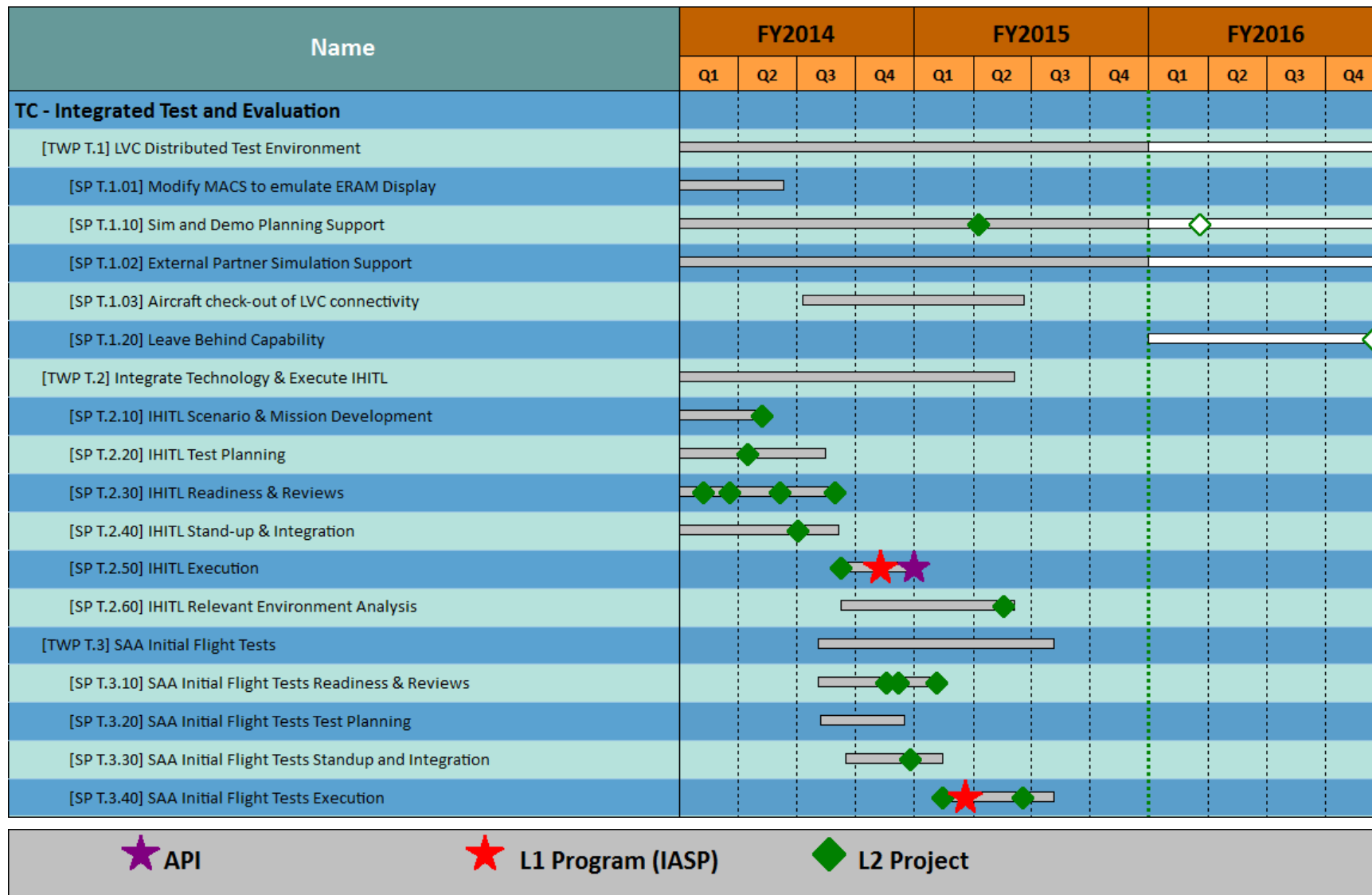


TC-ITE Test/Simulation	Baselined Execution Start Date	Test/Simulation Objective	Contribution to SC-228 MOPS
[SP T.5.60] FT4 Execution	2/2016	<ul style="list-style-type: none">Conduct Flight Test Series 4 integrating the latest SSI algorithms, Control and Non-Payload Communication System prototype, HSI displays, and active test aircraft sensors using the Live, Virtual, Constructive test environment and document the performance of the test infrastructure in meeting the flight test requirements	<ul style="list-style-type: none">Results inform acceptability of the live, virtual, constructive distributed test environment as a realistic test environment for use in verifying and validating MOPS

- Briefings, Papers, or Reports
 - Integrated Flight Test 4 Flight Test Report, Planned June 2015



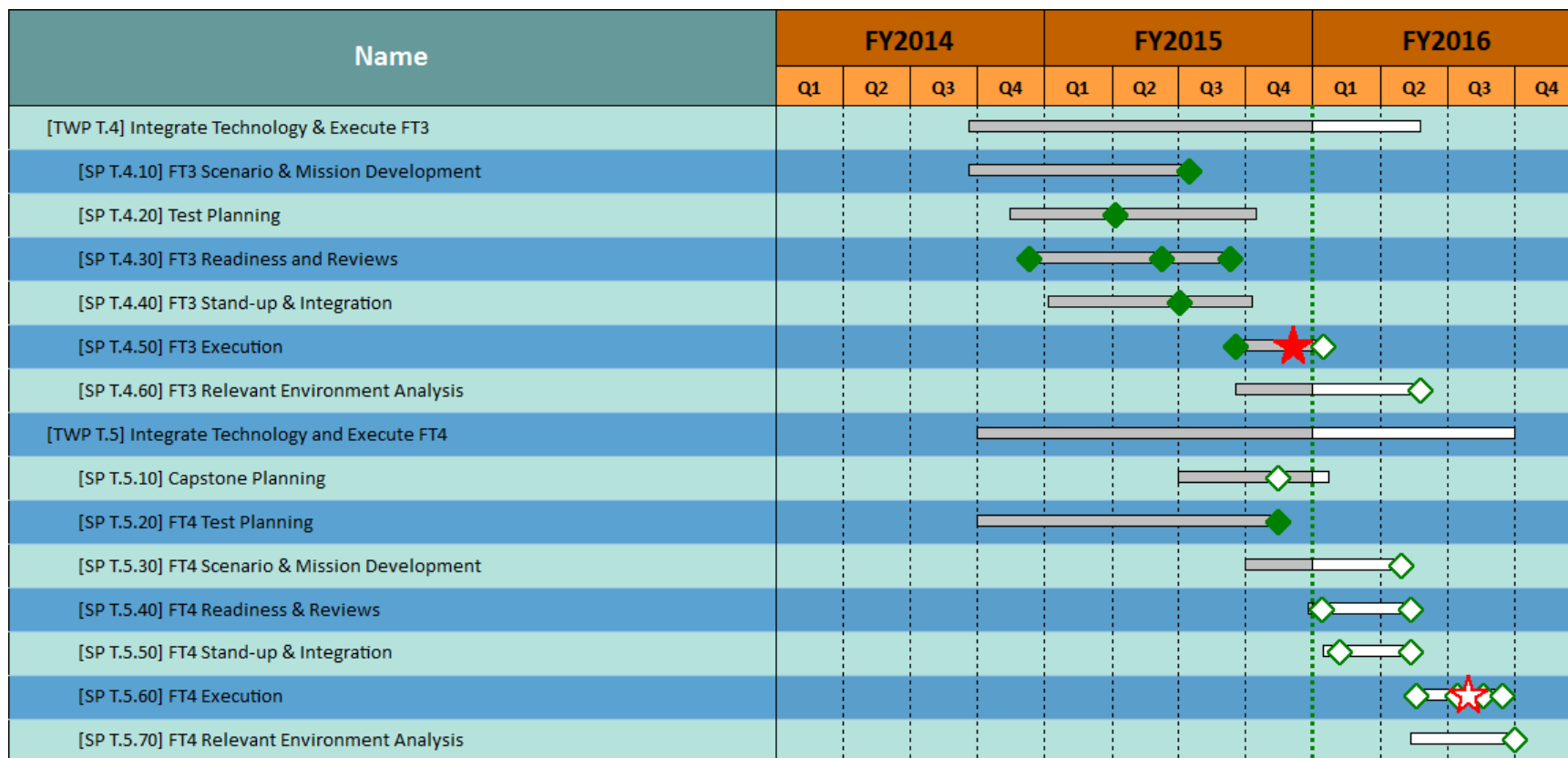
TC – ITE (1 of 2)



Green Status Line Date 9/30/15



TC – ITE (2 of 2)



API

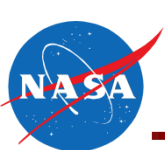


L1 Program (IASP)









L2 Project

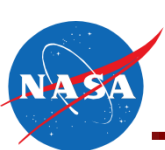
Green Status Line Date 9/30/15



FT4 Full Mission Ownship Evaluation Summary








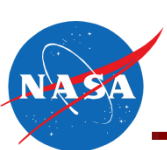
Required	Ownship DAA Phase 1 MOPS Sensor Suite (2 of 3 sensors required)					Autopilot Interface (Heading and Altitude Control from C2 link with GCS)	RGCS C2 Interface (latency from cmd execution to a/c response ≤2 sec)	Contract	Overall Assessment (see following chart for additional details)
Desired Aircraft	ADS-B (1090 IN/OUT)	Mode S Transponder (TCAS I)	A/A Radar (8 nm detection range, 20° x 30° FOR)	TCAS II (v7.1)	Tracker/ Sensor Fusion				
 AFRC Ikhana (870)	Equipped (BAE DPX-7)	N/A	Equipped (GA-ASI EDM DRR)	Equipped (HON TPA-100)	Equipped (GA-ASI/HON SAAP)	Full UAS (C2 link with Ikhana GCS)	Can not implement in time	Existing (GA-ASI Ikhana Support)	Developing RGCS connectivity can not be completed in time due to IT Security constraints
 NGC Firebird Demonstrator	Equipped (L3 TCAS/ADS-B)	N/A	Must be Integrated (AFRL/CEI A/A Radar integration planned)	Equipped (L3 TCAS/ADS-B)	Equipped (NGC Airborne SAAP)	Surrogate UA (C2 link with NGC GCS but onboard pilot must acknowledge cmds)	Must be Integrated (NGC GCS G2 is already STANAG 4586 compliant)	Need	Could support FT4 Full Mission but must acquire a timely contract and address experimental airworthiness cert that requires onboard pilot acknowledgements
 Calspan Learjet	Must be Integrated	Must be Integrated	Not an option	Must be Integrated	Must be Integrated	Surrogate UA (Calspan Variable Stability System but no C2 link)	Must be Integrated	Existing (AFRC-Calspan BPA)	Developing a C2 link and RGCS connectivity can not be completed in time
 AdvAero Avanti	Equipped (but need interface to ADS-B data)	Must be Integrated	Must be Integrated	Equipped (but need interface to TCAS data)	Must be Integrated	Surrogate UA (Heading control only and no C2 link with GCS)	Must be Integrated	Need	Developing a C2 link and RGCS connectivity can not be completed in time
 GRC T-34C (608)	Equipped (GDL-88)	Must be Integrated	Not an option	Must be Integrated	Not an option	Surrogate UA (S-TEC 55X equipped but has only heading control and cmd execution to a/c response latencies in excess of 2 sec)	CNPC	N/A	Assessment to be provided by joint AFRC/GRC independent review team
 GRC S-3B (601)	Must be Integrated (GDL-88 planned)	Must be Integrated	Must be Integrated	Must be Integrated (HON TPA-100 planned)	Must be Integrated	Must be Integrated	CNPC	N/A	Assessment to be provided by GRC



FT4 Full Mission Ownship Evaluation Summary (con't)



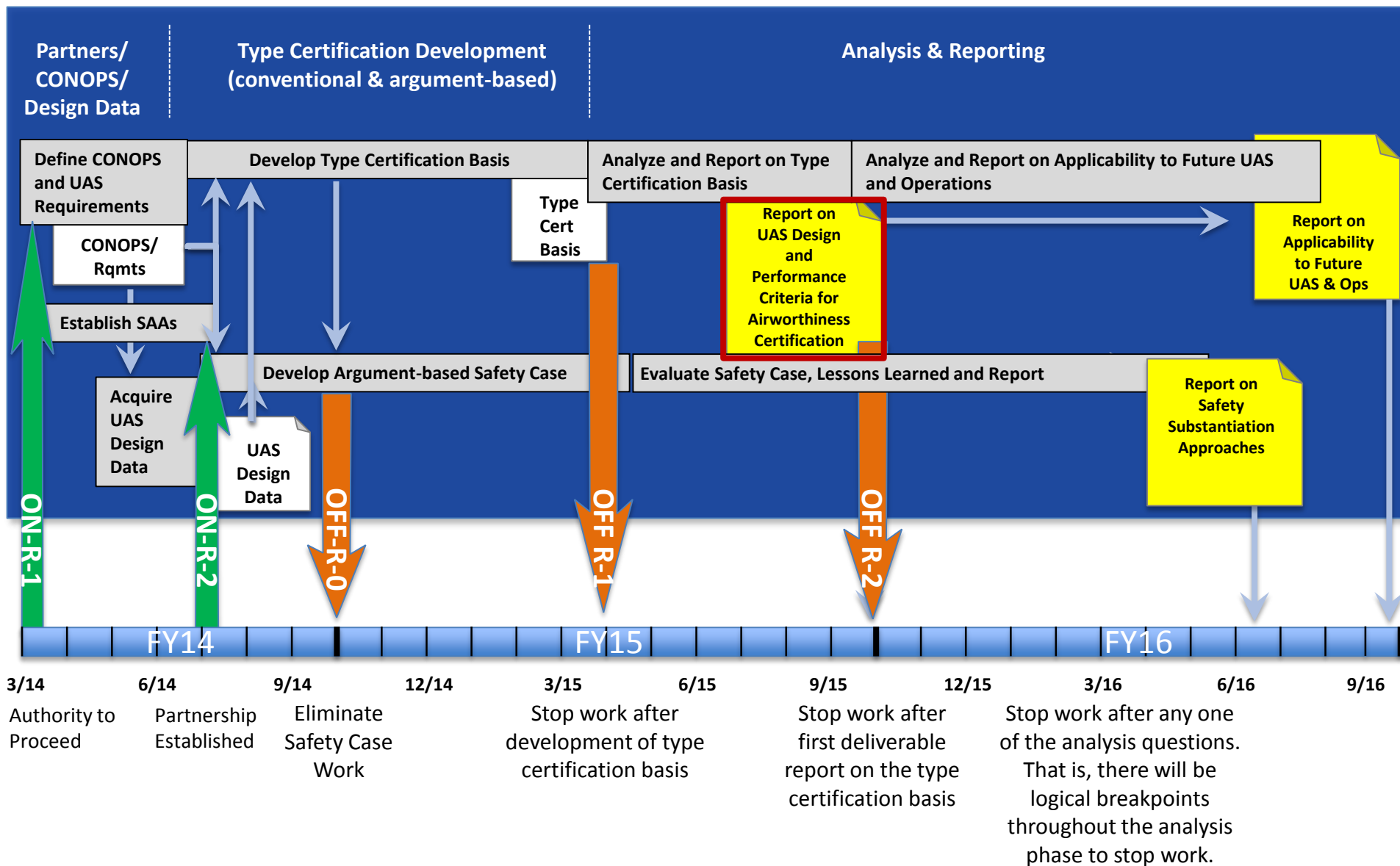
<div>Required</div> <div>Desired</div> <div>Aircraft</div>	Ownship DAA Phase 1 MOPS Sensor Suite (2 of 3 sensors required)					Autopilot Interface (Heading and Altitude Control from C2 link with GCS)	RGCS C2 Interface (latency from cmd execution to a/c response ≤2 sec)	Contract	Overall Assessment (see following chart for additional details)
	ADS-B (1090 IN/OUT)	Mode S Transponder (TCAS I)	A/A Radar (8 nm detection range, 20° x 30° FOR)	TCAS II (v7.1)	Tracker/ Sensor Fusion				
 LaRC SR-22 (501)	Must be Integrated (equipped with UAT only)	Not an Option	Not an Option	Not an Option	Must be Integrated	Surrogate UA (S-TEC 55X equipped but UHF C2 link with GCS is limited in range)	Must be Integrated (UHF C2 Link limited in range)	N/A	Unable to integrate 2 surveillance sensors
 LaRC HU-25C (525)	Equipped (but need interface to ADS-B data)	Must be Integrated	Must be Integrated	Equipped (but need interface to TCAS data)	Must be Integrated	Must be Integrated	Must be Integrated	N/A	Developing a C2 link and RGCS connectivity can not be completed in time
 AFRC GIII (502)	Must be Integrated	Must be Integrated	Must be Integrated	Equipped (but need interface to TCAS data)	Must be Integrated	AFRC Platform Precision Autopilot but no C2 link to GCS	Must be Integrated	N/A	Aircraft not available to support integration and test schedule
 JSC GIII (992)	Must be Integrated (GDL-88 planned)	Must be Integrated	Must be Integrated	Must be Integrated	Must be Integrated	Must be Integrated	Must be Integrated	N/A	Developing a C2 link and RGCS connectivity can not be completed in time
 AFRC GIII (808)									



UAS-NAS Non-Technical Challenge Work Backup Slides



Certification Task/Product View Timeline On/Off-Ramps

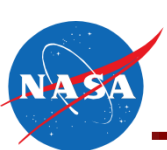


- ### 3-D Robotics Y-6

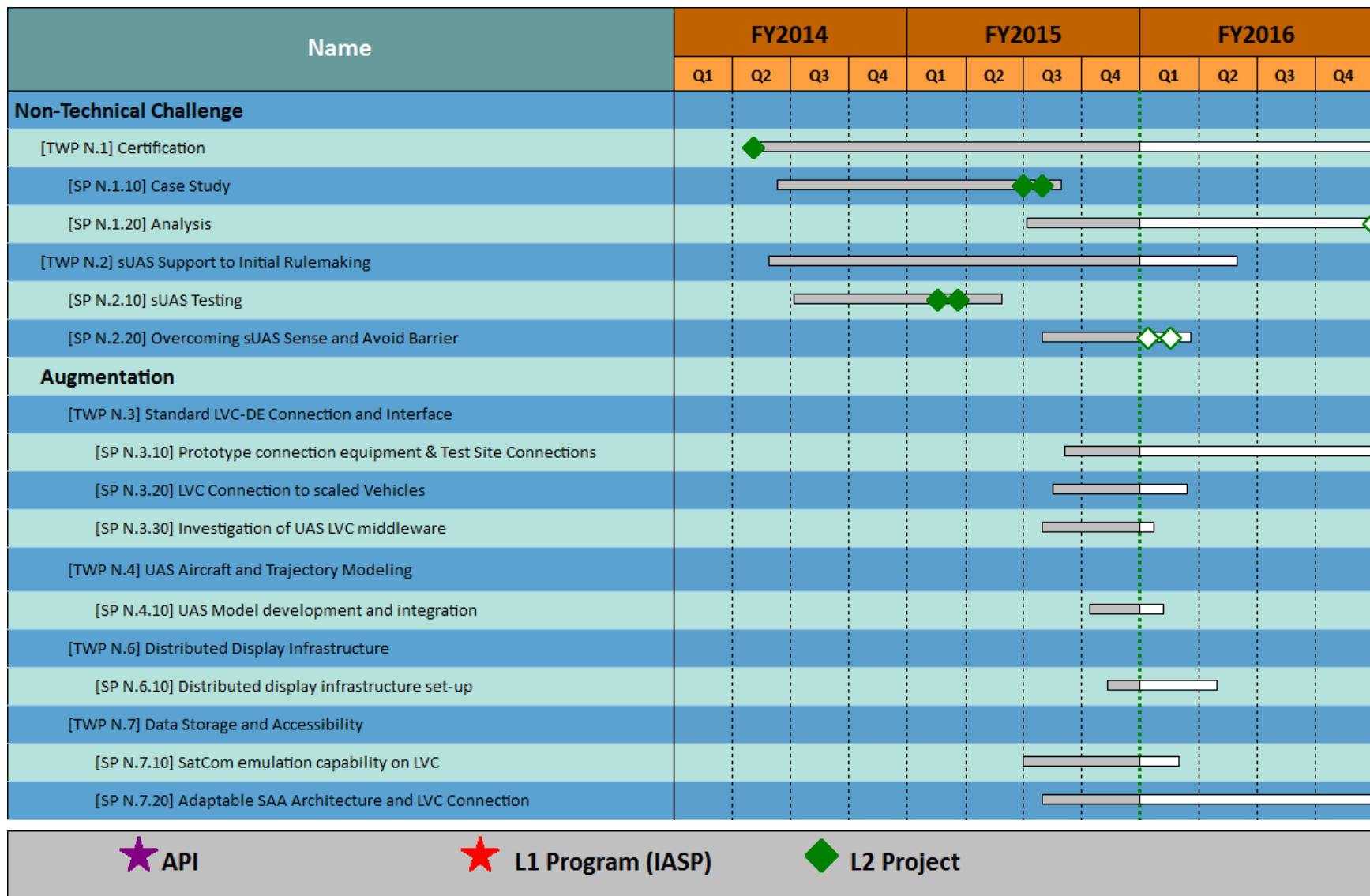


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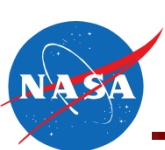




Non-Technical Challenges



Green Status Line Date 9/30/15



Augmentation Technical Status Summary



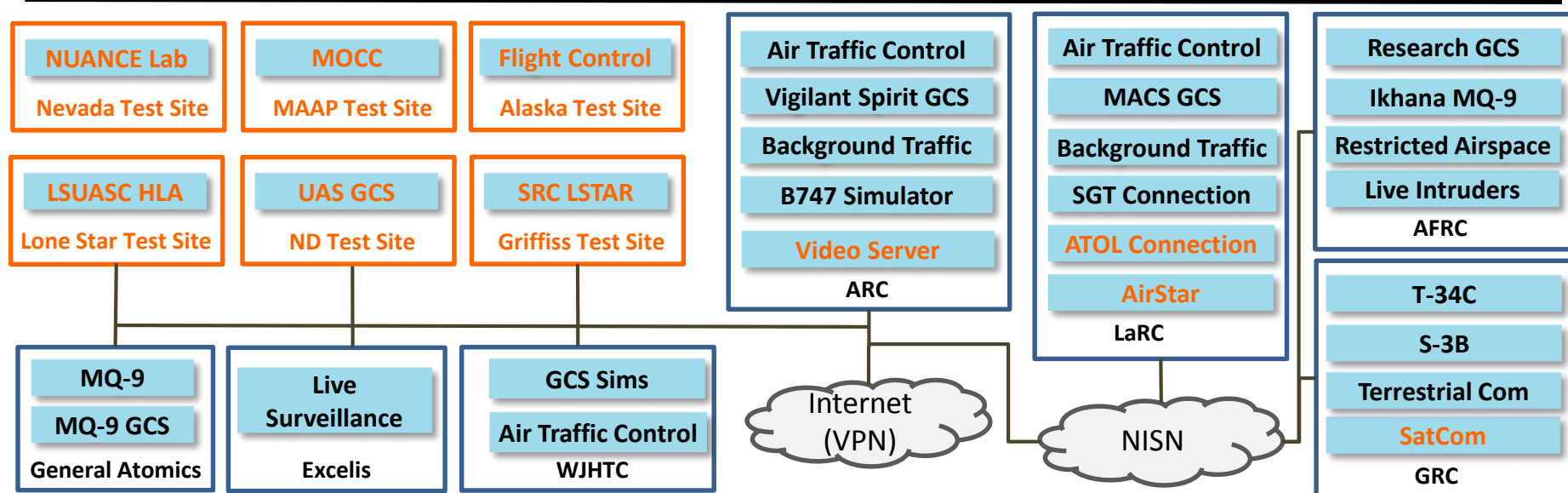
Task	Status
3.1 Prototype connection equipment & test site connections	Complete FY15: All Test Sites under contract to connect to the LVC Remaining FY16: All Test Sites will perform actual connection work in FY16
3.2 LVC connection to scaled vehicles	Complete FY15: Preparation for install complete, all hardware purchased, and some hardware installed Remaining FY16: Install remaining hardware, connect Airstar “mid-sized” UAS, demonstrate HLA bridge
3.3 Investigation of ideal middleware	Complete FY15: Report delivered documenting recommendations for short and long term connectivity. Recommendations will be used for Test Site Connections and other long term partners. Remaining FY16: none
4.1 VFR Traffic Model Development and Integration	Complete FY15: Processing VFR track data from 21 sample days, and apply a noise reduction algorithm Remaining FY16: Create ACES formatted scenario files, and use ACES to fully smooth the data, then deliver new, smoothed VFR track data by Nov 20
6.1 Distributed Display Infrastructure Set-up	Complete FY15: All hardware procured for each center Remaining FY16: Final installations and checkout
7.1 Satcom emulation capability on LVC	Complete FY15: Developed requirements, purchased hardware, performed initial lab testing Remaining FY16: Finalize software update on S-3B and perform LVC connectivity testing for flight test data collection
7.2 Adaptable SAA Architecture and LVC Connection	Complete FY15: GA under contract to deliver ARP capability Remaining FY16: Implement upgrades to allow NASA algorithms to run in place of current SAA-related algorithms to command vertical speed and heading changes



Standard LVC Connection and Interface



- Technical Objectives:
 - Investigate LVC middleware options for future simulations and flight testing
 - Establish connection between each UAS Test Site and the LVC
 - Develop interface and test connection between scaled models and LVC

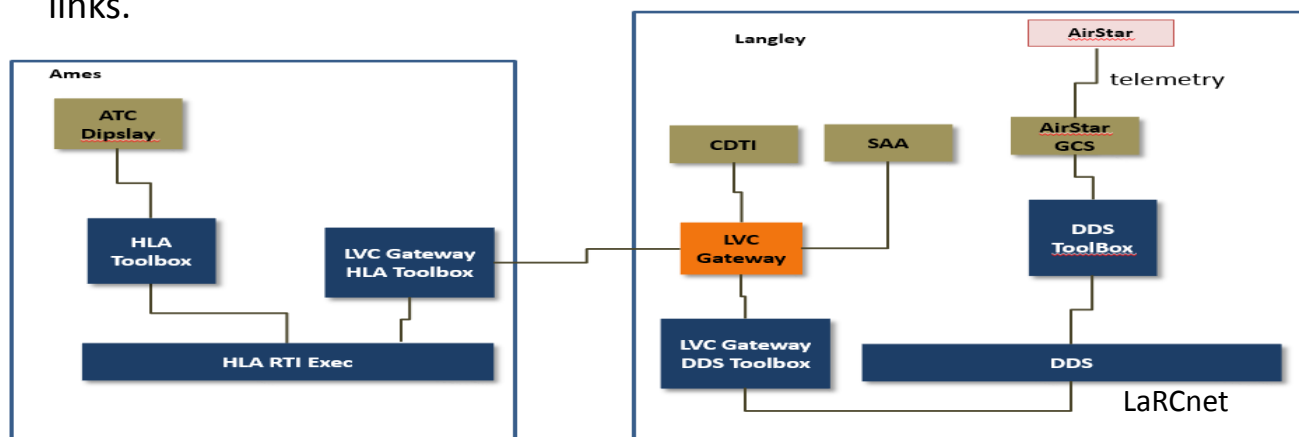


- Significant Results, Conclusions, and Recommendations:
 - LVC middleware report outlines strategies for long term LVC connectivity
 - All 6 UAS Test sites under contract; planning prototype connection test FY16 Q3
 - Initial connection of LaRC AirStar system to LVC complete; check-out test expected in December

Investigation of ideal middleware; Prototype connection equipment & test site connections; LVC connection to scaled vehicles

- **Technical Objectives:**

- Develop Infrastructure to enable addition of vehicles into the LVC to conduct live testing of DAA algorithms for Phase 2 MOPS (BAT, AirStar, Flight Operations and Command Center)
- Create a UAS Research Data Collection and Repository (Actual Database Server SW and HW)
- Deploy and test Display software for Common Operating Picture for use in UAS Lab in Phase 2 MOPS Development.
- Establish LaRC as a full node on LVC: Include IT infrastructure, storage, connectivity, communication links.

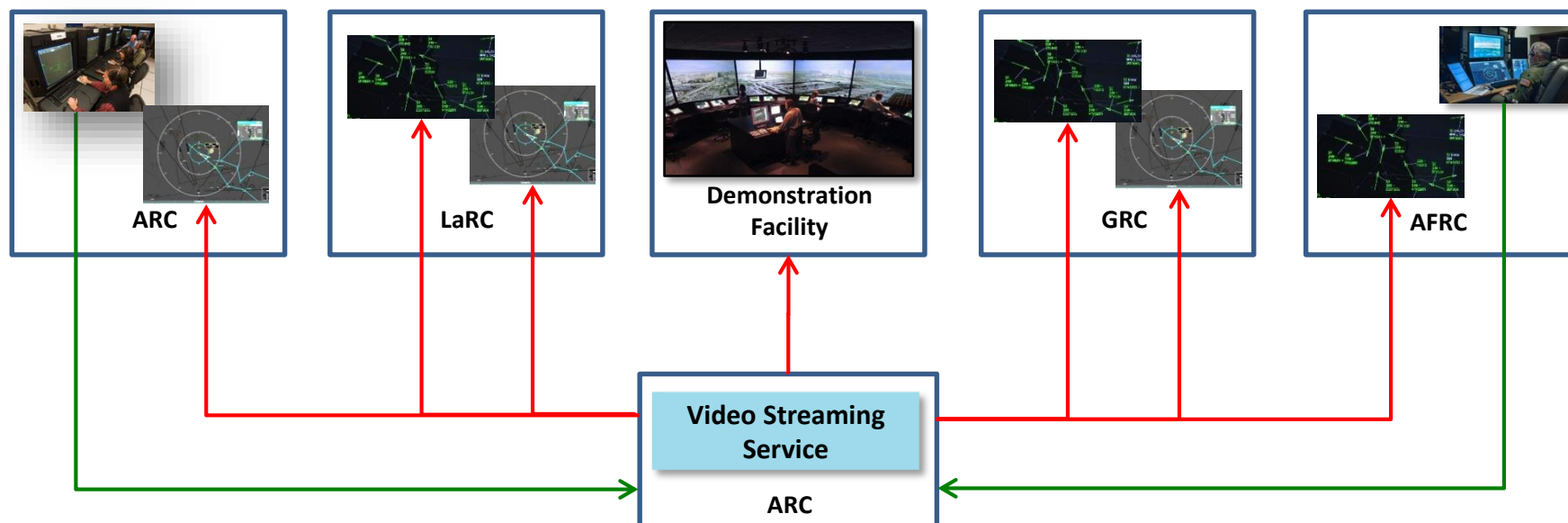


- **Significant Results, Conclusions, and Recommendations:**

- Performed architecture analysis
- Purchased and installed enabling hardware: LVC Gateway servers, AirStar hardware, Video wall installation pending
- DDS-LVC Gateway toolbox complete, pending gateway test; LVC Gateway installed
- DDS-HLA Bridge in development

Investigation of ideal architecture; Prototype connection equipment & center-to-center connections;
LVC connection to scaled vehicles

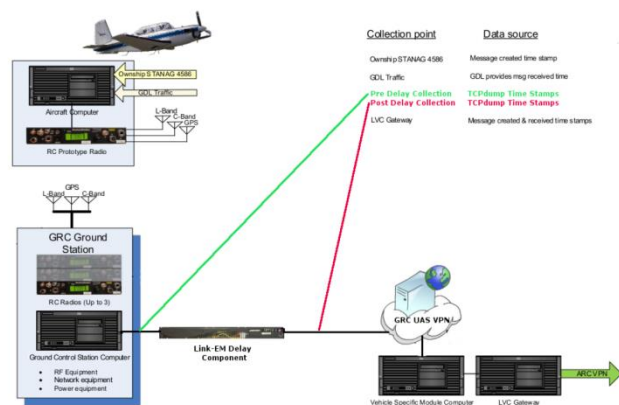
- Technical Objectives:
 - Develop the ability to share displays to be across locations connected to the LVC (i.e. aeronautics centers), without changing the test software or impacting test subjects
 - Update displays at Ames IT&E demonstration and tower facility



- Significant Results, Conclusions, and Recommendations:
 - Video streaming equipment procured and tested between AFRC and ARC
 - Video server and display equipment procured; connection between ARC and each Center in place; testing planned for FY16 Q1
 - Display projector bids under evaluation for FY16 installation

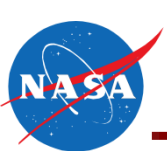


- Develop SatCom emulation capability and interface to LVC, in order to assist in the development of SatCom specifications and UAS operations ConOps under higher communication latency conditions.



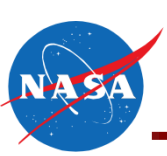
- Developed SatCom emulation requirements
- Developed SatCom emulation
- Performed initial lab testing of SatCom emulation
- Currently updating software on S-3B aircraft.
- Coordinating with ARC on LVC system connectivity for flight test data collection.

SatCom CNPC System Performance Requirements for C2 MOPS



UAS-NAS Capstone





Define & Apply Weighting Criteria



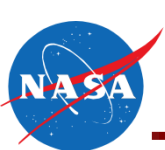
Opportunity: *Ability to accelerate schedule, reduce costs, and leverage technologies*

- Clarity and efficiency of implementation path
- Collaboration with others
- Leverage existing technologies and efforts

Risk: *Effects from not achieving the desired outcome*

- Size, complexity, and difficulty of implementation
- Negative impact on civil/commercial market
- Potential delays to full integration
- Degrading efficiency of the NAS (without degrading safety)

Benefit: *Impact toward achieving the overall vision of “full integration”*

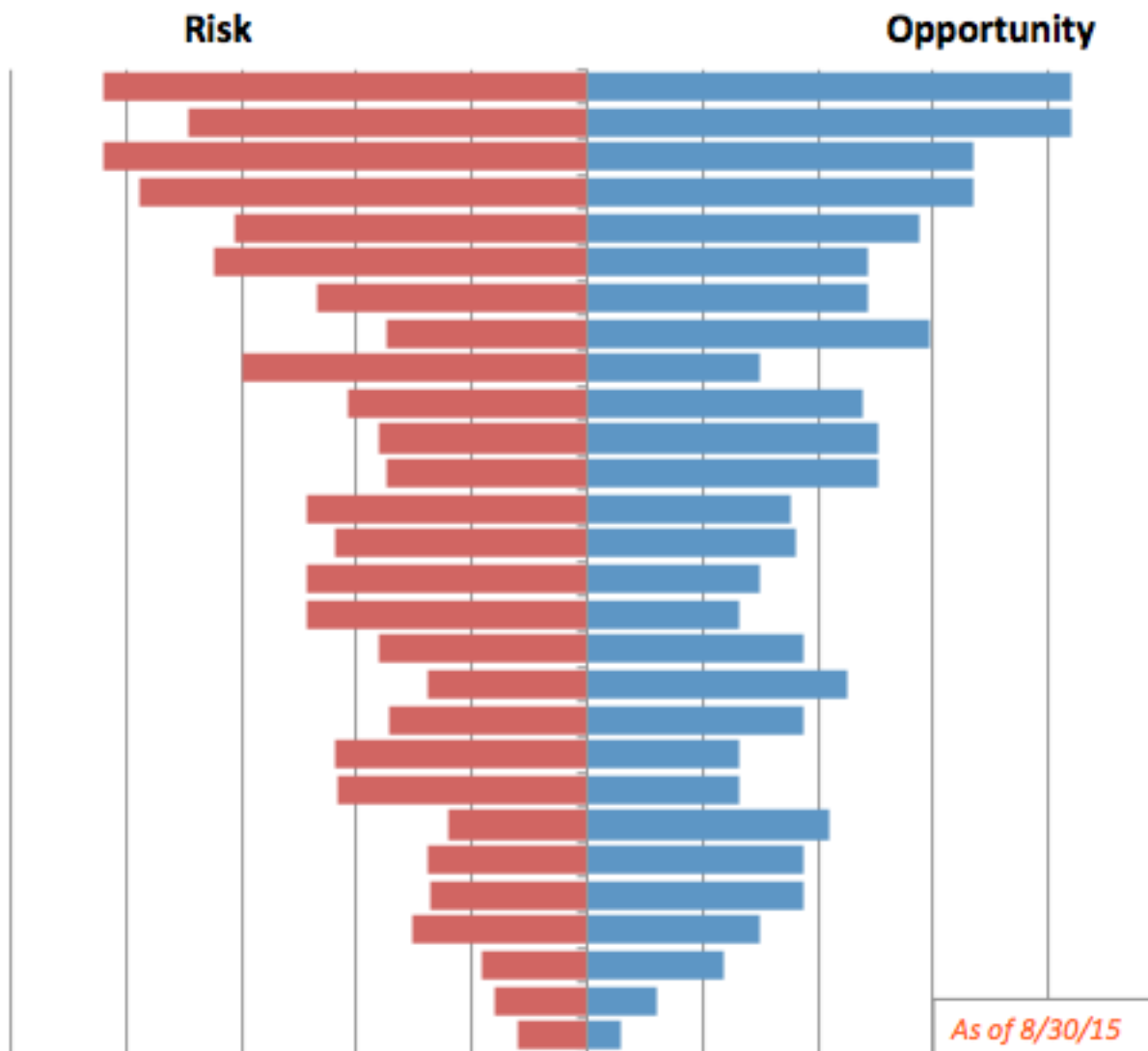


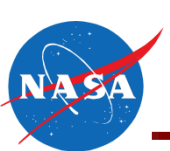
Prioritize Remaining Gaps

Benefit adjusted Opportunity / Risk Tornado Diagram



3c

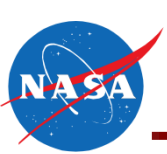




Prioritize Remaining Gaps

Lead / Collaborate / Leverage Recommendations

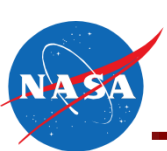




MOE Considerations

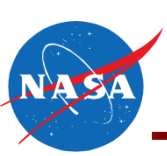


- Attendance: 30-40 people max
- Purpose: Attain consensus from the UAS community on...
 - Bin definitions
 - Vision/concepts of what it means to be complete
 - Gaps to achieve full integration
- Representation:
 - Various organizations (e.g. FAA, RTCA, DOD, AUVSI, Academia, Industry, etc)
 - Experts in each technical area (e.g. DAA, C3, Automation, Ops, etc)
- Recommendation: Separate audience into smaller break out groups
 - Read-ahead material and telecon 2 weeks prior will set the stage and instigate initial inputs/questions/comments for review
 - All attendees involved in every bin is inefficient, disengaging and will be very difficult to reach consensus
 - Most people will have knowledge overlapping multiple bins. Some bins will require more participation, or be more controversial
 - One MTSI person will facilitate each breakout session

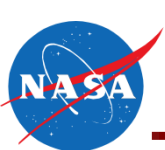


Phase 2 MOPS Support Planning





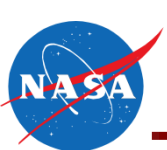
Project Processes Implementation Backup Slides



FY15 Significant Changes Against Baseline



CR(s)#	Area	Change	Impact (Cost, Schedule, Technical)
040	PO	Redefined L2 Milestones related to Comprehensive Research Report to reflect 1 final report. Final report was elevated to L1 Milestone – “Comprehensive FT4 Research Report”	Schedule, Technical
042, 043, 067	TC-SAA	Closed/eliminated SP S.3.20, “Well Clear Alerts/Resolutions with VFR and Pilot/Controller (ACES Simulation)” and added SP S.3.30, “Well Clear Alerting Logic, Methods, and Performance Requirements” to provide greater benefit to SC-228 by conducting work of greater importance to SC-228	Schedule, Technical
049	PO	Reallocated funds to LaRC for CASSATT efforts	Cost
053, 079	TC-HSI	Deletion of L2 Milestone – “HSI PT4B Briefing to RTCA” (CR053) and deletion of associated tasks (079) as briefing was to be completed by GA, and not HSI.	Schedule, Technical
058, 062	TC-ITE	Original FT4 Test Plan was broken into an ORD and the FT4/Capstone Test Plan. FT4/Capstone test plan was captured in CR062. Creation of L2 Milestone - SP T.5.50, “FT4/Capstone Flight Test Plan”	Schedule, Technical
064	Non-TC- sUAS	Additional work approved for sUAS – N.2.20 sUAS SAA Testing	Cost, Schedule, Technical
065	PO	L1 Milestone date changes to MOPS comments to coincide with SC-228 schedule	Schedule
070	Non-TC - Certification	Deletion of L2 Milestone. GSN Safety case did not meet the original intent of the deliverable	Cost, Schedule, Technical
080	TC-HSI	Reallocated funds to HSI for MUSIM efforts	Cost
083	TC-C2	Deletion of FT3 related milestone as subproject was not intending to use FT3 data to brief SC-228	Technical
086	ITE	Documentation of FT3 Completion.	Technical
088	TC-HSI	Deletion of FT3 related milestone. Data was found to be insufficient to brief to SC-228	Technical
091	PO	Reallocation of funds to cover the following: FAA Test Site efforts, TCAS II antenna, and to fund HSI grant with CSULB.	Cost



FT3 Related Change Requests

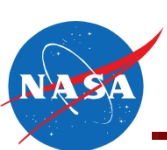


- Change Requests Related to Schedule

CR #	Project/ TC	Title /Description
014	SSI	TC-SAA L2 Milestone Changes; change in date for
020	HSI	TC-HSI L2 Milestone Changes in TWP H.1; change in date for HSI FT3 Briefing to RTCA
026	PO	ADD API Level 1 Milestone for FY16 – FT3
046	ITE	Change to FT3 Configuration Freeze date
047	ITE	Change to FT3 FDR Date
061	PO, SAA, C2, HSI, ITE	Change to FT3 Completion Date – L1 Milestone

- Change Requests Related to Technical

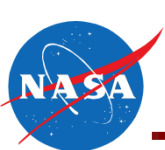
CR #	Project/ TC	Title /Description
014	SSI	TC-SAA L2 Milestone Changes; change in date for
086	PO	FT3 Completion
083	C2	TC Comm Level 2 Milestone deletion
088	HSI	TC HSI, SP H.1.50 Level 2 Milestone deletion



FT3 Related Risks



Risk ID	Project/ TC	Risk Title	Status
U.1.1.10	PO	Output from Test Events has value to Project Stakeholders	Mitigate
U.4.3.8	C2	Radios flight tested in FT3 and FT4 Series may not fully validate MOPS	Closed 7/31/2014
U.4.3.9	C2	FT3 CNPC Preparations Stressing C2 Preliminary MOPS Development	Closed 9/24/2015
U.4.3.10	C2	FT3 Radio Frequency Coverage	Closed 9/24/2015
U.4.3.11	C2	FT3 CNPC Equipment Installation at California	Closed 9/24/2015
U.4.1.4	SAA	A test bed for airborne sense and avoid flight tests equipped with the command and non-payload communications radio may not be available	Closed 10/16/2014
U.4.1.9	SAA	Delay of TC1/SSI Technology Developments Impact to Integrated Test Events (IHITL, FT3 and FT4)	Mitigate
U.4.2.9	HSI	Delay of TC3/HSI Technology Development Impact to Integrated Test Events (IHITL, FT3 and FT4)	Mitigate
U.4.2.11	HSI	Availability of Vigilant Spirit Control Station for Flight Test Series	Mitigate
U.5.1.7	IT&E	Distributed Test Environment requirements for Integrated Flight Test 3 (FT3) not defined	Closed 3/26/2015
U.5.1.10	IT&E	Required Assets for Flight Test 3 (FT3) not available during test period	Closed 8/20/2015
U.5.1.15	IT&E	Inability to achieve TCAS II Self-separation IHITL Objectives due to lack of an IT Security Authority to Operate (ATO)	Closed 4/17/2014
U.5.1.16	IT&E	Completion of TC6/IT&E Technical Objectives that Rely upon Formal Partnerships	Closed 5/23/2015
U.5.1.17	IT&E	The T-34 (UA Surrogate) for FT3 and FT4 may not be available	Watch
U.5.1.23	IT&E	No formal agreement in place to access Honeywell data fusion algorithm	Mitigate
U.5.1.24	IT&E	Timing of Part Task 5 impact on Flight Test 3 design	Closed 4/23/2015
U.5.1.25	IT&E	Shortage of Resources – AFRC IT Security Experts	Closed 7/23/2015
U.5.1.26	IT&E	ADS-B Receiver may not be received in time to support FT-3	Closed 8/20/2015
U.5.1.27	IT&E	FT-3 Ikhana and Intruder Pilot Availability	Closed 8/20/2015



The T-34 (UA Surrogate) for FT3 and FT4 may not be available



Subproject Execution

Risk ID:

U.5.1.17

Risk Owner:

Jim Griner

TC-ITE

Trend

Criticality



Current L x C

1 x 3

(Technical = 3,

Schedule = 3,

Cost = 1)

Target L x C

1 x 3

Open Date

11/25/13

with

1x5

Planned

Closure Date

TBD: Based on trade study completion



Risk Statement

Given the FT3 and FT4 activities require the T-34 be utilized as a UA surrogate aircraft (containing the CNPC radio), should the T-34 not be available for FT3 and/or FT4 the L1 milestones associated with FT3/FT4 will not be met.

Original Impact

Technical = 5. Should the T-34 not be available for flight test the L1 milestones associated with FT3 and FT4 will not be met.

Schedule = 5. A greater than 2 month schedule slip may be incurred if the T-34 aircraft is not available for flight test

Cost = 1. TBD

Status

9/24/2015: Risk not accepted for closure at MRB. Risk will remain in watch status.

9/15/2015: Risk proposed for closure.

8/18/2015: Risk will remain in watch. Need to review after FT3 meetings (August 24-25 and September 9-10).

12/4/14: Risk will remain in watch.

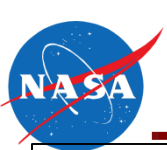
9/18/14: Reviewed risk during IT&E RWG meeting. Risk to trending flat (unchanged) at this time.

Risk Approach: Watch

Mitigation Trigger (if current action is Watch): At GRC airplane being considered to support other operations in same timeframe as FT3/FT4

Mitigation Step/Task Description:	Cost to Implement (if exceeds current budget)	Start Date	End Date	New LxC C: (Tech, Schedule, Cost)
Conduct Glenn T-34 replacement/back-up trade study for Flight Test 3. (Mitigation 01) COMPLETE		12/16/13	4/15/14	1x3 C: (T3,S3, C1)
Conduct Glenn T-34 replacement/back-up trade study for Flight Test 4. (Mitigation 02)		TBD	TBD	1x3 C: (T3,S3, C1)

Rationale for Closure:



Validation of SAA Sensor Models

Top Risk



Subproject Execution

Risk ID:

U.4.1.11

Risk Owner:
Santiago

**TC-SAA
TWP:**

Trend



Criticality

Med

Current L x C

3 x 3

(Technical = 3,
Schedule = 1,
Cost = 2)

Target L x C

2 x 2

Open Date

7/15/2014

with

3 x 3

**Planned
Closure Date**

1/19/2016

Risk Statement

Given the lack of access to a sensor suite that includes both cooperative and non-cooperative sensors (e.g. TCAS, ADS-B, EO/IR, airborne radar) there is a possibility that the validation of the sensor models used in ACES and PT6 won't be completed. Actual implementations of SAA capabilities will need to address real-world sensor uncertainties, and will be studied in simulation. Validation of the sensor models will require access to flight test platforms with sensor suites that include both cooperative and non-cooperative sensors (e.g. TCAS, ADS-B, EO/IR, airborne radar) to enable the validation of ACES results that will support surveillance requirements covered in the DAA MOPS. The completion of these research tasks may be impacted by lack of access to a sensor suite, since NASA does not own a flight asset with a SAA sensor suite.

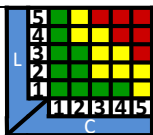
Status

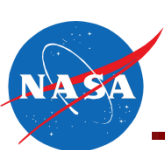
9/15/2015: Risk is trending flat. Integration of sensor model into ACES from Honeywell is going well. Matlab has been auto coded. Once complete, team will be testing against Matlab results to ensure there are no bugs. Team has the data from FT3 configuration 1 that passed through the Honeywell tracker. Data is sufficient to validate model. End date of mitigation 02 extended from 8/31/2015 to 10/31/2015 due to no-cost extension added to Honeywell contract.

8/17/2015: Risk is trending up. LxC score increases from 2x3 to 3x3. Integration and testing of models may not be complete by 8/31 (issue with generic fusion algorithm and not finished integration task). Honeywell is pursuing 2-month no-cost extension. This adds risks to PT6 and ACES sim using models. Mitigation 03 added.

Risk Approach: Mitigate

Mitigation Step/Task Description:	Cost to Implement (if exceeds current budget)	Start Date	End Date	New LxC C: (Tech, Schedule, Cost)
Contract out the validation of sensor models and tracking/fusion algorithms using data from representative flight tests (Mitigation 01) (Santiago) COMPLETE	FY15=\$190k FY14 = \$362k	7/15/14	9/30/14	3x3 C: (T3,S1, C2)
Execute representative flight tests and carry out validation of sensor models and tracking/fusion algorithms using flight test data (Mitigation 02) (Santiago)	NA	1/1/15	8/31/15 10/31/15	2x2 C: (T2,S1, C1)
Add task to Honeywell contract stating that they will supply their Data Fusion Software and support integration for PT6 and "comprehensive" ACES simulation. (Mitigation 03) (Santiago)		8/17/15	1/19/16	2x2 C: (T2,S1, C1)





Required Assets for Flight Test 4 (FT4) not available during test period



Top Risk

Subproject Execution

Risk ID:

U.5.1.11

Risk Owner:
Kim/Murphy

TC-ITE

TWP: ITE

Trend



Criticality

Med

Current L x C

3 x 3

(Technical = 2
Schedule = 3
Cost = 1)

Target L x C

1 x 3

Open Date

4/11/13

with

3 x 3

Planned

Closure Date

1/4/16

Risk Statement

Distributed Test Environment assets required to execute Flight Test 4 are not available during the data collection period, FT4 reporting and closeout. This will impact L1 milestone UAS/NAS FY16 Annual Performance Indicator (API) and FT4 test planning activities and schedule. Technical delays in integrating components of the Distributed Test Environment results in schedule slips past test event milestones.

Original Impact

Technical = 2; This will put the L1 milestone UAS/NAS FY16 Annual Performance Indicator (API) at risk.

Schedule = 3; Technical delays in integrating components of the Distributed Test Environment results in schedule slips past test event milestones.

Cost = 1; Bringing in additional WYEs or FTEs will not prevent slippage in schedule because appropriate skill mix is needed

Status

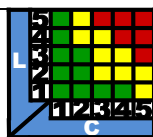
9/15/2015: Mitigation 01 includes all assets including identifying intruders. End dates for mitigations 01 and 1A extended from 9/30/2015 to 11/13/2015. End dates for mitigations 02 and 03 extended from 10/16/2015 to 11/13/2015 to coincide with the FT4 ERT. Review of risk is ongoing through FT4 path forward and decision point 2 (Nov 13) outcome.

8/20/15: Need to review/clean-up risk after post FT3/FT4 path forward meetings (August 24-25 and September 9-10).

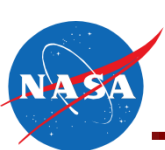
8/18/15: Jim Murphy provided updated text for Mitigation 1A.

Risk Approach: Mitigate

Mitigation Step/Task Description:	Cost to Implement	Start Date	End Date	New LxC
Determine required FT4 assets (including facility and equipment requirements). [Kim/Murphy/All PEs] (Mitigation 01)	TBD	1/15/15	9/30/15 11/13/15	2 x 3 (T2,S3, C1)
Create plan and schedule for procuring long lead facilities or equipment identified during requirements gathering and system design and track integration into the test environment. If necessary, track asset procurement and integration under a separate risk.(Mitigation 1A)	TBD	7/20/2015	9/30/15 11/13/15	2 x 3 (T2,S3, C1)
Develop rapid prototype interfaces into the LVC for new components. [Kim/Murphy/All PEs] (Mitigation 02)	NA	4/11/13	10/16/15 11/13/15	2 x 3 (T2,S3, C1)
Schedule assets that meet specified requirements for the time periods that cover the testing and conduct of FT4. [Kim/Murphy/All PEs] (Mitigation 03)	NA	1/15/15	10/16/15 11/13/15	1 x 3 (T2,S3, C1)
Identify and procure key equipment that can be readily replaced if failure occurs during testing and where procurement of a replacement is economically feasible. [Kim/Murphy/All PEs] (Mitigation 04)	TBD	10/1/14	1/4/16	1 x 3 (T1,S3, C1)



Distributed Test Environment requirements for Integrated Flight Test 4 (FT4) not defined



Top Risk

Project Success

Risk ID:

U.5.1.8

Risk Owner:
Kim/Murphy

TC-ITE

TWP: ITE

Trend



Criticality

Med

Current L x C

2 x 3

(Technical = 2
Schedule = 3
Cost = 1)

Target L x C

1 x 3

Open Date

3/16/13

with

3 x 3

**Planned
Closure Date**

10/13/15

Risk Statement

Given timely definition of system requirements is necessary in order to ensure proper development of the environment, delayed execution of FT4 reporting and closeout will impact the execution of the L1 milestone Capstone Event and FY16 Project reporting and closeout by Sep 30th, 2016.

Original Impact

Technical = 3; If LVC system requirements are not defined per schedule then FT4 L2 dates will not be met.

Schedule = 3; The Level 1 milestone, UAS/NAS FY14 Annual Performance Indicator (API) will be at risk.

Cost = 1; De-Scope

Status

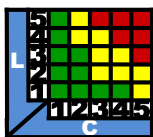
9/15/2015: Mitigation 03 is complete. End dates of mitigations 04 and 05 extend from 8/31/2015 to 10/31/2015. Review of risk is ongoing through FT4 path forward and decision point 2 (Nov 13) outcome.

8/20/15: Need to review/clean-up risk after post FT3/FT4 path forward meetings (August 24-25 and September 9-10).

8/6/15: Risk continues to trend flat. End date for Mitigation 03 extended from 7/31/15 to 8/31/15. Documented the radar requirement and noted that IT&E is not going to meet it.

Risk Approach: Mitigate

Mitigation Step/Task Description:	Cost to Implement (if exceeds current budget)	Start Date	End Date	New LxC C: (Tech, Schedule, Cost)
Conduct IHITL SRR to define draft and include all known FT3 and FT4 requirements for inclusion in IHITL SRR. (Mitigation 01) COMPLETE	N/A	8/15/13	11/7/13	2 x 3 C: (T3,S3, C1)
Define draft and include all known FT4 requirements for inclusion in FT3 SRR. (Mitigation 02) COMPLETE	N/A	8/15/13	9/10/2014	2 x 3 C: (T2,S3, C1)
Work with the researchers to define and baseline specific FT4 objectives and test requirements and disseminate them to the key stakeholders for review. (Mitigation 03) COMPLETE	N/A	3/25/15	7/31/15 7/15/15 8/21/15	2 x 3 C: (T2,S3, C1)
Lessons learned from Flight Test 3 Activity will be applied to FT4. (Mitigation 04)	N/A	9/1/14	8/31/15 10/31/15	2 x 3 C: (T1,S3, C1)
Complete the FT4 specific requirements document with inputs from FT3 lessons learned and stakeholder responses to the baseline. (Mitigation 05)	N/A	3/25/15	8/31/15 10/31/15	1 x 3 C: (T1,S3, C1)
Develop the ITE architecture description document by baselining the FT3/FT4 architecture for the Distributed Test Environment (Mitigation 06)	N/A	6/6/13	10/13/15 11/13/15	1 x 3 C: (T1,S3, C1) 174





Output from Test Events has value to Project Stakeholders



Top Risk

Project Success

Risk ID:

U.1.1.10

Risk Owner:

Randall

Project

Trend



Criticality

Med

Current L x C

2 x 3

(Technical =3,

Schedule = 2,

Cost = 2)

Target L x C

2 x 3

Open Date

4/24/14

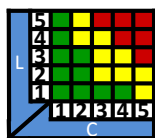
with

3 x 4

Planned

Closure Date

7/1/16



Risk Statement

Given the diversity of testing to be conducted and schedule and cost constraints, it is possible that the type/kinds of data collected during tests may not be sufficient or timely for MOPS development.

The Project is conducting subproject individual and joint testing, and the integrated test events. Output from these events need to provide value to the Project Stakeholders. Superseded risk

[U.5.1.5.](#)

Status

9/15/15: LxC and additional mitigations will be assessed based upon FT4 path forward and decision point 2 (Nov 13) outcome.

8/6/15: Risk is trending up. Loss of radar on S3-B caused a significant change to what was planned. May add additional mitigations as result of next steps.

7/20/15: Risk continues to trend flat. Hosting four members from SC-288 DAA V&V working group at AFRC July 20th and 21st. Plan to support SC-288 DAA V&V working group meeting in Phoenix August 11-13.

6/4/15: Risk is trending flat. Debra Randall briefed SC-228 and explained how to communicate requirements that they wanted for FT4 and how NASA would take those requirements in and determine if we would meet them or not. On May 29th Debra briefed Code R on plan to coordinate with stakeholders.

Risk Approach: Mitigate

Mitigation Step/Task Description:

*Closed mitigations listed in notes section (Mitigations 01, 02, 03, 05 09)

Provide the Project L1/L2 Milestones, Milestone Dates, and Project Requirements Document to our Stakeholders [FAA (ANG-80, AFS-80), SC-228 DAA and C2 Working Groups, and SARP] ([Mitigation 04](#))

NASA project personnel coordinate with SC-228 working group peers to identify opportunities for flight test 4 to support development of MOPS requirements. Then brief test design, plans, and objectives to SC-228 WG ([Mitigation 06](#))

NASA project personnel coordinate with SC-228 working group peers to identify opportunities for subproject test events to support development of MOPS requirements. Then brief test design, plans, and objectives to SC-228 WG. ([Mitigation 07](#))

NASA Project personnel to brief test objectives, design, and plans to FAA personnel and obtain stakeholder feedback for FT3 & FT4. ([Mitigation 08](#))

Original Impact

Technical = 4; Technology maturation may be moderately impacted by a failure of the Project to deliver data products relevant to the needs of our Project Stakeholders.

Schedule = 3; Added flight or simulation events will slip schedule.

Cost = 2; If the Project needs to add a flight or simulation event to collect data due to non-delivery of relevant data to a stakeholder, then the marching army costs for the event could be an issue.

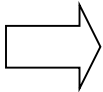
Mitigation Step/Task Description: *Closed mitigations listed in notes section (Mitigations 01, 02, 03, 05 09)	Cost to Implement	Start Date	End Date	New LxC C: (Tech, Schedule, Cost)
Provide the Project L1/L2 Milestones, Milestone Dates, and Project Requirements Document to our Stakeholders [FAA (ANG-80, AFS-80), SC-228 DAA and C2 Working Groups, and SARP] (Mitigation 04)	NA	3/1//14	9/30/15	2x3 C: (T3, S2, C2)
NASA project personnel coordinate with SC-228 working group peers to identify opportunities for flight test 4 to support development of MOPS requirements. Then brief test design, plans, and objectives to SC-228 WG (Mitigation 06)	\$0	3/1/14	1/15/16	2x3 C: (T3, S2, C2)
NASA project personnel coordinate with SC-228 working group peers to identify opportunities for subproject test events to support development of MOPS requirements. Then brief test design, plans, and objectives to SC-228 WG. (Mitigation 07)	\$0	3/1/14	7/1/16	2x3 C: (T3, S2, C2)
NASA Project personnel to brief test objectives, design, and plans to FAA personnel and obtain stakeholder feedback for FT3 & FT4. (Mitigation 08)	\$0	10/1/14	3/30/15 10/1/15	2x3 C: (T3, S2, C2)

UAS-NAS Project Focus Changes Due to External Influences



Risk ID: 02

Trend



Criticality

Med

Current L x C

2 x 3

(Technical = 3,
Schedule = 3,
Cost = 3)

Open Date

4/12/12

with
3 x 3

Planned Closure Date

7/15/16

Risk Statement

Discussions between NASA, FAA and others in the UAS community were used to identify project Technical Challenges, which were used to scope project content during Formulation. These activities continue to refine the UAS integration in the NAS efforts at the national level through roadmap development. While IASP and the UAS-NAS Project participate in these activities, resultant changes to the UAS roadmap could lead to changes in UAS-NAS Project content. This risk captures the potential for loss of relevance of UAS-NAS work content and the potential that stakeholder/customer needs might change.

Status

4/9/15: Updated risk to reflect FY15 ARMD restructure nomenclature with new Program name IASP

03/13/14: Worked with UAS-NAS Project Risk team and Stuart to create new mitigation steps on 2/19/14. The FAA Roadmap and JPDO Comprehensive Plan were released on November 7th, 2013. This in turn closed our second mitigation.

01/08/14: RTCA SC-228 White papers have been through the FRAC process as of 12/6/2013 and the white papers should be released through the PMC in the March timeframe. NASA work has been evaluated against white papers and the portfolio does not appear to require changes in focus. Additionally, NASA has worked closely with the SARP at Well Clear and Deep Dive workshops to ensure relevance of other SAA and HSI TWP's.

11/14/13: This risk will likely be lowered with the release of the white paper. The stability and maturity of SC-228 should also lower this risk.

8/22/13: Likelihood decreased to 2 based on: Independent assessment from the NAC; participation in SC-228; and development of Phase 2 portfolio that is aligned with ARC implementation plan, FAA ConOps and JPDO comprehensive plan.

4/25/13: RTCA released a new ToR which eliminated SC-203 and new Minimum Operational Performance specs, and FAA got rid of their SSI-related objective. Changes re being accounted for via KDP planning for Phase 2. Present mitigations remain effective.

6/12/12: Established monthly meetings with FAA UAS Integration office

4/12/12: Risk baselined

3/9/12: Risk brought to RMB. Action given to reword and bring back to RMB.

1/31/12: Risk brought to RMB as a Candidate Risk but deferred for further discussions if this should be a Project or Program risk.

Risk Action: Mitigate

Mitigation Trigger (if current action is Watch): When external efforts that could result in possible changes to UAS-NAS scope are on-going.

Impact

Planned activities in the UAS-NAS Project may not be relevant, resulting in significant project replanning.

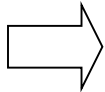
Rationale for Closure:

UAS-NAS Project Focus Changes Due to External Influences



Risk ID: 02

Trend



Criticality

Med

Current L x C

2 x 3

(Technical = 3,
Schedule = 3,
Cost = 3)

Open Date

4/12/12

with

3 x 3

**Planned
Closure Date**

7/15/16

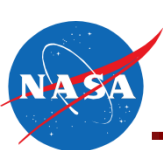
Risk Statement

Discussions between NASA, FAA and others in the UAS community were used to identify project Technical Challenges, which were used to scope project content during Formulation. These activities continue to refine the UAS integration in the NAS efforts at the national level through roadmap development. While IASP and the UAS-NAS Project participate in these activities, resultant changes to the UAS roadmap could lead to changes in UAS-NAS Project content. This risk captures the potential for loss of relevance of UAS-NAS work content and the potential that stakeholder/customer needs might change.

Impact

Planned activities in the UAS-NAS Project may not be relevant, resulting in significant project replanning.

Mitigation Step/Task Description:	Cost to Implement	Start Date	End Date	New L x C
Remain involved with major policy making, shareholder, and stakeholder organizations (FAA-UAS-PO, RTCA SC-228, DoD, MIT-LL, AFRL, etc.). Gain FAA agreement on NASA body of research/technology developments.	\$0		End of Project	2 x 3
Remain cognizant of FAA and JPDO roadmapping efforts to provide insight to FAA and JPDO thinking on research and technology development needs. The delivery date for these roadmaps is unknown so the mitigation will end upon publication.	\$0		Closed 11/7/13	2 x 3
Remain cognizant of FAA integration efforts to provide insight to FAA thinking on research and technology development needs.	\$0		End of Project	2 x 3
Participation in the RTCA SC-228 working groups, SARP, UAS Senior Steering Group of ExCom, and UAS Aviation Rulemaking Committee.	\$0		Release of Final MOPS 7/15/16	2 x 3



RTCA SC-228 Requirements Development Delay



Watch

Project Success

Risk ID:

U.1.1.12

Risk Owner:

Grindle

Project

Trend



Criticality



Current L x C

3 x 5

(Technical = 5,
Schedule = 3,
Cost = 1)

Target L x C

3x3

Open Date

10/16/14

with

3 x 5

Planned

Closure Date

12/31/2015

Risk Statement

Given the DAA and C2 WG are continuing to refine the requirements and V&V plans, and given the project technical objectives and schedule have been baselined there is a possibility the requirements they define will impact the project baseline technical objectives and schedule. As an example the CNPC radio, originally designed to SC-203 seedling requirements, continues to be refined based on developing C2 MOPS.

Original Impact

Technical = 5; The UAS-NAS Project technical baseline is aligned with anticipated SC-228 MOPS needs. Unknown whether the baseline plan will be consistent with undelivered MOPS and V&V plans if they are delivered late to ToR schedule.

Schedule = 3; minimum impacts L1 milestones (NASA feedback to the MOPS).

Cost = 1; Project would be met per baseline cost.

*** Note: Assumed SC-228 Preliminary MOPS slip impacts planning and execution of FT4

Status: 5/21/15: MRB approved moving risk to watch status. *Risk was TOP RISK – due to original LxC score 3x5 (red). No longer a top risk due to watch status.*

5/19/15: During PPBE 17 the Project provided ARMD/IASP with a proposed follow-on project which would decrease the likelihood. The Project has done everything it can do until this risk is triggered. Mitigations are actively being worked. If risk is triggered then approved contingency plan will be implemented. Proposed to move into watch status. Trigger will be RTCA SC-228 schedule delay.

4/13/15: Project Office Risk Workshop held. Received action at IASP/UAS RMB on April 9th to review scores. Examined LxC scores and the likelihood of 3 is consistent with information from WG meetings in the absence of something more definitive from leadership. The consequence score reflects impact of not completing the technical challenge.

Risk Approach: Watch

Mitigation Trigger (if current action is Watch): The trigger is **RTCA SC-228 schedule delay**.

Mitigation Step/Task Description:	Cost to Implement	Start Date	End Date	New LxC
Integrate NASA personnel into SC-228 C2 working groups to understand and influence C2 WG requirements and their impacts on the Flight Test planning, and share C2 research, objectives, plans, and results with C2 WG. (Mitigation 01) [Griner]	\$0	9/5/14	12/31/15	3x3 C (T3, S3, C1)
Integrate NASA personnel into DAA working groups to understand and influence DAA MOPS requirements and their impacts on the Flight Test planning (Mitigation 02) [Arthur/Santiago]	\$0	9/5/14	12/31/15	3x3 C (T3, S3, C1)

Contingency Plan - Project Controlled Contingency Plan on next slides.

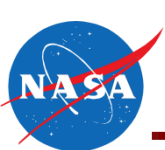
- Word Document located on KN at <https://nsckn.nasa.gov/DMS/ViewDoc.aspx?DocID=743920>

- IASP Controlled Contingency Plan captured in mitigation below

Work towards extending the life of the Project or including appropriate Project personnel in another ARMD activity to support the SC-228 Phase 2 MOPS.

RTCA SC-228 Requirements Development Delay

Contingency Plan (1 of 2)



Risk ID 1.1.12. Risk Statement Given the SC-228 detect and avoid (DAA) and command and control (C2) Data Link Working Groups (WG) are continuing to develop their Minimum Operational Performance Standards (MOPS) and MOPS verification and validation (V&V) plans, and given the project technical objectives and schedule were baselined to reasonably support the published SC-228 schedule, there is a possibility that potential changes to the MOPS or V&V plans development schedules or requirements will impact the project baselined technical objectives and schedule.

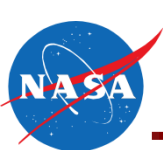
As an example the UAS-NAS project is developing a prototype control and non-payload communication (CNPC) radio for use in MOPS development and MOPS V&V. A CNPC radio is one of several key technologies required for MOPS development and MOPS V&V. As CNPC radios take several years to design and build the NASA CNPC prototype radio design was initiated with RTCA SC-203 seedling requirements. While the design of the radio continues to mature, there is risk that changes in C2 Working Group MOPS may not be implementable in the CNPC radio design if they are too extensive or require more schedule than is available within the UAS-NAS Project.

Background: RTCA SC-228 is the primary stakeholder to the majority of the Project's research portfolio. The SC-228 Terms of Reference (TOR) defined requirements with respect to developing MOPS for DAA, and C2. The requirements included producing Preliminary MOPS and a MOPS V&V Plan by July 2015 (Phase One), and Final MOPS based on the MOPS V&V by July 2016 (Phase Two). The two phases of SC-228 are unrelated to the two phases of the UAS-NAS Project. Both DAA and C2 have independent working groups defining MOPS for the respective technology areas. The working groups each have elements of Human Systems Integration embedded. NASA's research activities contribute to developing Preliminary MOPS, supporting MOPS V&V, and developing Final MOPS for each respective Working Group. The technology transfer process for NASA research findings described below will be relevant to MOPS development Phase 1 only, UAS-NAS Project Phase 2.

The UAS-NAS Project baselined milestone dates are generally aligned with the SC-228 MOPS delivery dates. The risk is whether the UAS-NAS Project's baseline technology transfer of research findings plan can support MOPS development and MOPS V&V plans if the results from those efforts are delayed later than the Project can adapt or when delivered the results are significantly different from the UAS-NAS initial assumptions.

NASA is participating in SC-228 at all levels.

- From a project management level the UAS-NAS Project is coordinating a strategy for documenting deliverables to SC-228. Laurie Grindle, Davis Hackenberg, and Debra Randall attend the Plenary sessions to maintain awareness at a high level.
- NASA is a key contributor at the working group level to within several sub working groups. Project participation in the SC-228 working groups by the subproject PE's (Confesor Santiago, Maria Consiglio, Jay Shively, Jim Griner) provides a method of influencing MOPS requirements and feeding back SC-228 discussions into UAS-NAS Project plans.



RTCA SC-228 Requirements Development Delay

Contingency Plan (2 of 2)



Risk ID 1.1.12. Contingency Plan: Assuming the RTCA SC-228 Preliminary and Final MOPS delivery schedules slip or the MOPS or MOPS V&V Plans are substantially different from initial Project assumptions the UAS-NAS Project may not be able to adapt based upon Project currently baselined Level 1 and Level 2 Milestones.

Assumptions:

- 1) Next FY President's Budget includes the extension of funding to the first quarter of FY17.
- 2) No additional funding available for changes to the Project baseline within baselined project completion date of Sep 30, 2016 (EOFY16).
- 3) No additional funding available to extend the Project beyond the first Quarter of FY17.

The following general scenarios are possible and provided for potential contingency plan discussions:

If	Then	Potential Impact to Project Cost, Schedule, Technical Baseline	Potential Impact to SC-228
All SC-228 changes to MOPS or MOPS V&V Plan can be accommodated within Project Cost Baseline (that includes the one quarter funding extension)	Project accommodates changes by moving Milestones or modifying Technical Baseline	<ul style="list-style-type: none">• Cost: 1, funded with already approved one quarter extension• Schedule: 5, potential up to 3-month slip to Project Level 1 or 2 Milestones• Technical Baseline: 4, potential moderate impact to objective, technical challenge, or technology maturation	<ul style="list-style-type: none">• None• Consequence = 1
Some of SC-228 changes to MOPS or MOPS V&V Plan can be accommodated within Project Cost Baseline (that includes the one quarter funding extension)	Project accommodates those changes it can by moving Milestones or modifying Technical Baseline, but not incurring costs approved the approved cost baseline (that includes the one quarter funding extension)	<ul style="list-style-type: none">• Cost: 1, funded with already approved one quarter extension• Schedule: 5, potential up to 3-month slip to Project Level 1 or 2 Milestones• Technical Baseline: 4, potential moderate impact to objective, technical challenge, or technology maturation	<ul style="list-style-type: none">• Some Project results delivered per changed Project baselined schedule and Technical Baseline do not meet SC-228 MOPS or MOPS V&V Plan needs• Consequence = 2 - 4
SC-228 changes to MOPS or MOPS V&V Plan cannot be accommodated within Project Cost Baseline (that includes the one quarter funding extension)	Project does not change Baseline Milestone Schedule or Technical Baseline	<ul style="list-style-type: none">• None as the Project does not make any changes to approved Schedule Baseline or Technical Baseline	<ul style="list-style-type: none">• Project results delivered per Project baselined schedule and Technical Baseline do not meet SC-228 MOPS or MOPS V&V Plan needs• Related to risk U.1.1.10 Output from Test Events has value to Project Stakeholders• Consequence = 5

Risk Matrix						
L I K E L I H O O D	5					
	4					
	3			4.3.5		
	2					
	1					
		1	2	3	4	5
CONSEQUENCE						

Risk ID	Trend	LxC	Target LxC	Approach	Risk Title
4.3.5	➡	3x3	2x1	M	Additional Spectrum Analysis Requirements
5.1.17	NA	1x3	2x2	W	The T-34 (UA Surrogate) for FT3 and FT4 may not be available

As of 9/30/15

- Changes Since 2014 Annual Review
 - Added 3 Risks (4.3.9, 4.3.10, 4.3.11)
 - Closed 6 Risks (4.3.2, 4.3.4, 4.3.6, 4.3.9, 4.3.10, 4.3.11)
 - Moved risk 5.1.17 from TC-IT&E to TC-C2

Criticality	L x C Trend	Approach
High	⬇ Decreasing (Improving)	A- Accept RA - Raise
Med	⬆ Increasing (Worsening)	M - Mitigate E - Elevate
Low	➡ Unchanged	W - Watch C - Close
(T) Indicates a Top Risk		

Risk Matrix						
L I K E L I H O O D	5					
	4					
	3			4.1.11		
	2			4.1.9		
	1					
		1	2	3	4	5
		CONSEQUENCE				

Risk ID	Trend	LxC	Target LxC	Approach	Risk Title
4.1.11 (T)	➡	3x3	2x2	M	Validation of SAA Sensor Models
4.1.9	➡	2x3	1x3	M	Delay of SAA/SSI Technology Developments Impact to Integrated Test Events (IHITL, FT3 and FT4)
4.1.10	NA	2x2	2x2	W	Completion of SAA/SSI Technical Objectives that Rely upon Formal Partnerships

As of 9/30/15

Criticality	L x C Trend	Approach
High	⬇ Decreasing (Improving)	A- Accept RA - Raise
Med	⬆ Increasing (Worsening)	M - Mitigate E - Elevate
Low	➡ Unchanged	W - Watch C - Close
	(T) Indicates a Top Risk	R- Research

- Changes Since 2014 Annual Review
 - Closed 2 Risks (4.1.7, 4.1.8(T))

Risk Matrix						
L I K E L I H O O D	5					
	4					
	3			4.2.9		
	2		4.2.8			
	1			4.2.11		
		1	2	3	4	5
CONSEQUENCE						

Criticality	L x C Trend	Approach
High	↓ Decreasing (Improving)	A- Accept RA - Raise
Med	↑ Increasing (Worsening)	M - Mitigate E - Elevate
Low	→ Unchanged	W - Watch C - Close
	(T) Indicates a Top Risk	R- Research

Risk ID	Trend	LxC	Target LxC	Approach	Risk Title
4.2.9	↑	3x3	1x1	M	Delay of HSI Technology Development Impact to Integrated Test Events (IHITL, FT3 and FT4)
4.2.8	↓	2x2	2x2	M	Endorsement of HSI GCS Guidelines from a Recognized Standards-based Group
4.2.11	→	1x3	1x3	M	Availability of Vigilant Spirit Control Station for Flight Test Series
4.2.10	NA	2x2	2x2	W	Completion of HSI Technical Objectives that Rely upon Formal Partnerships

As of 9/30/15

- Changes Since 2014 Annual Review
 - Closed 1 Risk (4.2.12)
 - Moved 1 Risk to Watch (4.2.10)

Risk Matrix						
L I K E L I H O O D	5					
	4					
	3			5.1.11	5.1.23	
	2			5.1.8		
	1					
		1	2	3	4	5
		CONSEQUENCE				

Risk ID	Trend	LxC	Target LxC	Approach	Risk Title
5.1.23	↓	3x4	1x1	M	No formal agreement in place to access Honeywell data fusion algorithm
5.1.11 (T)	→	3x3	1x3	M	Required Assets for Flight Test 4 (FT4) not available during test period
5.1.8 (T)	→	2x3	1x3	M	Distributed Test Environment requirements for Integrated Flight Test 4 (FT4) not defined

As of 9/30/15

Criticality	L x C Trend	Approach
High	↓ Decreasing (Improving)	A- Accept RA - Raise
Med	↑ Increasing (Worsening)	M - Mitigate E - Elevate
Low	→ Unchanged	W - Watch C - Close
	(T) Indicates a Top Risk	R- Research

- Changes Since 2014 Annual Review
 - Added 3 Risks (5.1.25, 5.1.26, 5.1.27)
 - Closed 9 Risks (5.1.7(T), 5.1.10, 5.1.16, 5.1.21, 5.1.22, 5.1.24, 5.1.25, 5.1.26, 5.1.27)

Risk Matrix						
L I K E L I H O O D	5					
	4					
	3					
	2					
	1					
		1	2	3	4	5
CONSEQUENCE						

Risk ID	Trend	LxC	Target LxC	Approach	Risk Title
4.4.5	NA	2x3	1x2	W	Availability of Designated Engineering Representatives Resources

As of 9/30/15

- Changes Since 2014 Annual Review
 - Moved 1 Risk to Watch (4.4.5)

Criticality	L x C Trend	Approach
High	Decreasing (Improving)	A- Accept RA - Raise
Med	Increasing (Worsening)	M - Mitigate E - Elevate
Low	Unchanged	W - Watch C - Close
(T) Indicates a Top Risk		R- Research

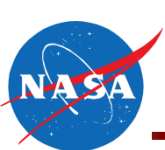
Risk Matrix						
L I K E L I H O O D	5					
	4					
	3	1.1.11				
	2			IASP 02 1.1.10		
	1				1.1.14	
		1	2	3	4	5
CONSEQUENCE						

Risk ID	Trend	LxC	Target LxC	Approach	Risk Title
IASP 02 (T)	➡	2x3	1x1	M	Project Focus Changes Due to External Influences
1.1.10 (T)	⬆	2x3	2x3	M	Output from Test Events has value to Project Stakeholders
1.1.11	➡	3x2	1x2	M	Lack of Definition for Capstone
1.1.14	➡	4x1	2X1	M	Capstone Partnership Development and Formalization
1.1.12 (T)	NA	3x5	3X3	W	RTCA SC-228 Requirements Development Delay

Criticality	L x C Trend	Approach
High	⬆ Decreasing (Improving)	A- Accept RA - Raise
Med	⬆ Increasing (Worsening)	M - Mitigate E - Elevate
Low	➡ Unchanged	W - Watch C - Close
	(T) Indicates a Top Risk	R- Research

- Changes Since 2014 Annual Review
 - Added 1 Risk (1.1.14)
 - Accepted 1 Risk (1.1.7)
 - Closed 1 Risk (1.1.4(T))
 - Moved 1 Risk to Watch (1.1.12)

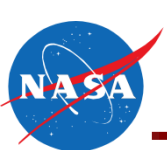
As of 9/30/15



Risks Accepted/Closed (1 of 3)



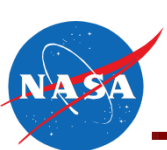
Risk ID	Project/ TC	Risk Title	Date Closed	Closing Rationale
U.4.3.2	C2	Communication Security Requirements Exceed CNPC Link Constraints	4/23/15	All mitigations are complete reducing the LxC to target score of 1x3. Comm team has worked with Rockwell Collins and RTCA to approve data rates for communication link. All security functions needed are being handled by that data rate.
U.4.3.4	C2	Availability of OPNET Modeler Expertise	12/18/14	Mitigations are complete resulting in a LxC score of 1x2. Contractor has been hired on and trained. There is no longer an issue in this area.
U.4.3.6	C2	Higher Communications Aircraft Fuel Cost	9/24/15	As FT3 has concluded and GRC aircraft are not being used in FT4, there is no further basis for this risk.
U.4.3.9	C2	FT3 CNPC Preparations Stressing C2 Preliminary MOPS Development	9/24/15	As both the preliminary C2 MOPS and FT3 have been completed, there is no longer a basis for this risk.
U.4.3.10	C2	FT3 Radio Frequency Coverage	9/24/15	Mitigation 2 was completed, indicating the frequency coverage for FT3 was adequate. FT3 has been completed, and there is no longer a basis for this risk.
U.4.3.11	C2	FT3 CNPC Equipment Installation at California	9/24/15	Installation of FT3 CNPC equipment was installed at a single alternate site at AFRC. As FT3 has been completed, there is no longer a basis for this risk.
U.4.1.7	SAA	Lack of Collision Avoidance Model Availability and Integration Support	4/21/15	All mitigations are complete reducing the LxC to target score of 1x3. SAA integrated TCAS II model and is using it for testing.
U.4.1.8	SAA	Sense and Avoid Sensor Suite Availability	12/18/14	All mitigations are complete resulting in a target LxC score of 2x2. Partnership with GA is established and plans are in place to equip Ikhana.



Risks Accepted/Closed (2 of 3)



Risk ID	Project/ TC	Risk Title	Date Closed	Closing Rationale
U.4.2.12	HSI	New Requirements associated with HSI Part Task 5	12/18/14	Additional WYE has been hired. Mitigation 01 is complete, reducing the LxC from 4x3 to 2x2
U.5.1.7	ITE	Distributed Test Environment requirements for Integrated Flight Test 3 (FT3) not defined	3/26/15	The Flight Test 3 requirements have been gathered and vetted through the System Requirements Review, presented to our stakeholders for comment, and finalized at the Final Design Review. All Mitigations have been successfully completed.
U.5.1.10	ITE	Required Assets for Flight Test 3 (FT3) not available during test period	8/20/15	FT3 deemed complete on 8/13/2015.
U.5.1.16	ITE	Completion of TC6/IT&E Technical Objectives that Rely upon Formal Partnerships	4/23/15	GA Space Act Agreement with NASA has been signed. Any required modifications are being tracked by the Project Office. Mitigations tracked by IT&E have been successfully completed.
U.5.1.21	ITE	Aggressive ACAS-Xu Flight Test Schedule Jeopardizes Full Success Criteria	1/27/15	All mitigations were implemented successfully to complete the ACAS-Xu CA flight testing on time. Although the AFSR schedule was impacted by 1 week, close coordination with the FRR Board Members resulted in an uneventful AFSR Review and subsequent flight test approval.
U.5.1.22	ITE	Compressed AFSR Schedule Results in Schedule Delay	12/18/14	All mitigations were implemented successfully to complete the ACAS-Xu CA flight testing on time. Although the AFSR schedule was impacted by 1 week, close coordination with the FRR Board Members resulted in an uneventful AFSR Review and subsequent flight test approval.



Risks Accepted/Closed (3 of 3)



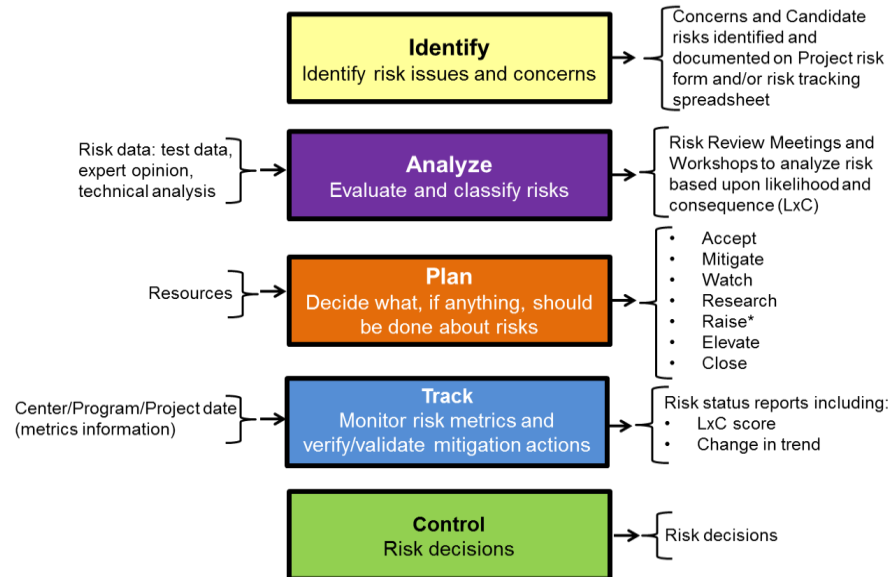
Risk ID	Project/TC	Risk Title	Date Closed	Closing Rationale
U.5.1.24	ITE	Timing of Part Task 5 impact on Flight Test 3 design	4/23/15	The Flight Test 3 design has been reviewed and finalized at FDR. All mitigations were completed and the system is on track for data collection.
U.5.1.25	ITE	Shortage of Resources – AFRC IT Security Experts	7/23/15	Full ATO signed on June 29. ATO was granted to the Ikhana project. Risk has been fully mitigated reducing the LxC to target score of 1x4 (green).
U.5.1.26	ITE	ADS-B Receiver may not be received in time to support FT-3	8/20/15	A second receiver is scheduled to be delivered 8/17. The first receiver will be repaired prior to FT4 and will be used as a backup. Given FT4 is six months away, IT&E does not consider this a risk.
U.5.1.27	ITE	FT-3 Ikhana and Intruder Pilot Availability	8/20/15	FT3 deemed complete on 8/13/2015
U.1.1.4	PO	The predicted or projected UAS mission profiles and traffic estimates used by the subprojects for their technology development efforts may not be realistic or accurate.	3/26/15	All mitigations are complete resulting in a target LxC score of 1 x 3.
U.1.1.7	PO	Negative Public Perception of UAS in NAS	12/18/14 Accepted	All mitigations are captured in the UAS-NAS Public Outreach plan reducing the LxC to 2x3. Outreach tasks have been added to the IMS. Project has allocated a set amount of resources and feel that is the limit to what we want to contribute to influence the public's opinion.

- Risk Management
 - Utilizes a Continuous Risk Management (CRM) process to identify, analyze, plan, track, and control risks
 - Risk Workshops and Risk Review meetings conducted monthly
 - Integrated Test & Evaluation Subproject holds a weekly risk working group meeting to address their risks
 - Risks are communicated in IASP UAS-NAS Risk Review Board, AFRC & Partner Center CMCs



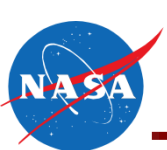
Path Forward to address Process Failure

- To gain higher perspective, Project Manager and Management Support Specialist will implement monthly risk brainstorming meeting to review concerns and discuss any potential new concerns/candidate risks



Note: Communication and documentation extend throughout all functions.

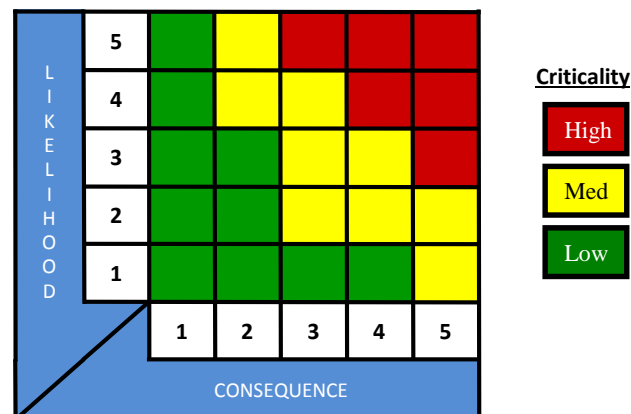
*Raise: unique to UAS-NAS Project



UAS-NAS Risk Summary Card

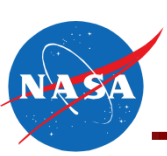


LIKELIHOOD		
5	Very High	Qualitative: Nearly certain to occur. Controls have little or no effect.
4	High	Qualitative: Highly likely to occur. Controls have significant uncertainties.
3	Moderate	Qualitative: May occur. Controls exist with some uncertainties.
2	Low	Qualitative: Not likely to occur. Controls have minor limitations /uncertainties.
1	Very Low	Qualitative: Very unlikely to occur. Strong Controls in Place

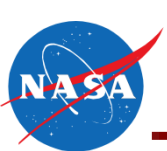


CONSEQUENCE	1	2	3	4	5
Technical	Negligible Impact to Objective, Technical Challenge, Technology Maturation	Minor Impact to Objective, Technical Challenge, Technology Maturation	Some Impact to Objective, Technical Challenge, Technology Maturation	Moderate Impact to Objective, Technical Challenge, Technology Maturation	Major Impact/Cannot Complete to Objective, Technical Challenge, Technology Maturation
Cost	≤ 1% Total Project Yearly Budget (≤ \$300K)	1% - 5% Total Project Yearly Budget (\$300K - \$1.5M)	5% - 10% Total Project Yearly Budget (\$1.5M - \$3M)	10% - 15% Total Project Yearly Budget (\$3M - \$4.5M)	>15% Total Project Yearly Budget (> \$4.5M)
Schedule *	Level 2 Milestone(s): < 1 month impact	Level 2 Milestone(s): ≥ 1 month impact	Level 1 Milestone(s): ≤1 month impact Level 2 Milestone(s): ≤ 2 month impact	Level 1 Milestone(s): > 1 month impact Level 2 Milestone(s): > 2 month impact	Level 1 Milestone(s): > 2 month impact Level 2 Milestone(s): ≥ 3 month impact

Note: L1 = ISRP L2 = Project

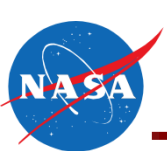


Project Level Performance Backup Slides



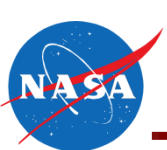
Reserve Strategy





Resource Allocation FY16 Budget





FY15 Project Deliverables



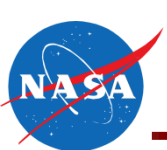
Phase 2 Technical Challenge Deliverables - SAA	Date	Type of Deliverable
Completed, Ongoing, and Upcoming Experiments IHITL/B747-TCAS and IHITL/CAS2 Overview and Results	Nov-14	Briefing
Pilot Detect-and-Avoid Evaluation	Nov-14	Briefing
Investigating the Impacts of a Separation Standard for UAS Enroute and Transition Airspace	Nov-14	Paper
UAS CAS3 CASSAT PER/FER	Mar-15	Briefing
Fast Time Simulation Studies	May-15	Briefing
Detect and Avoid Research	May-15	Briefing
Characterizing the Effects of a Vertical Time Threshold for a Class of Well-Clear Definitions	May-15	Paper
Appendix A NAS wide evaluation using historical radar data and airspace	May-15	Paper
UAS in the NAS Air Traffic Controller Acceptability Study - 1 the Effects of Horizontal Miss Distances on Simulated UAS and Manned Aircraft Encounters	May-15	Briefing & Paper
UAS Air Traffic Controller Acceptability Study 2 - Effects of Communications Delays and Winds in Simulation	May-15	Paper
Airspace Safety Threshold Study- NAS-wide Encounter Rate Evaluation using Historical Radar Data and ACES	May-15	Briefing
Analysis of Baseline PT5 Alerting Scheme in Fast-Time Simulations without DAA Mitigation	May-15	Briefing
Characteristics of a Well Clear Definition and Alerting Criteria for Encounters between UAS and Manned Aircraft in Class E Airspace	Jun-15	Paper
DAIDALUS: Detect and Avoid Alerting Logic for Unmanned Systems	Sep-15	Paper
HITL Experimental Research for DAA	Sep-15	Briefing
Detect and Avoid Alerting Logic for Unmanned Systems	Sep-15	Briefing



FY15 Project Deliverables



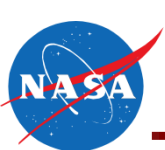
Phase 2 Technical Challenge Deliverables – C2	Date	Type of Deliverable
Gen-4 and Gen-5 Radio Plans	Dec-14	Briefing
V & V Update	Dec-14	Briefing
CNPC Prototype Gen 2 Security Architecture Lab Test Report	Dec-14	Report
Security Risk Assessment Process for UAS in the NAS CNPC Architecture	Aug-13	Report
CNPC System Development and Testing	Apr-15	Briefing
CNPC Prototype Radio - Gen 2 Security Architecture Lab Test Report	Jun-15	NASA TM
Phase 2 Technical Challenge Deliverables – HSI	Date	Type of Deliverable
Measured Response The effect of GCS Control Mode Interfaces on Pilot Ability to Comply with ATC Clearances	Oct-14	Briefing
A report on the Human Systems Integration Phase 1 Activities	Oct-14	Briefing
IHITL: Detect and Avoid Display Evaluation Prelim Results	Nov-14	Briefing
HSI Display Evaluation Overview	Mar-15	Briefing
NASA's UAS Integration into the NAS: A Report on the Human Systems Integration Phase 1 Simulation Activities	May-15	Briefing
Human Performance Issues in Remotely Piloted Aircraft Systems	Mar-15	Briefing
Automation in Unmanned Aerial Vehicles	Mar-15	Briefing
Part Task 5 Detect and Avoid Display Evaluation Overview III	May-15	Briefing
An Evaluation of DAA Displays for Unmanned Aircraft Systems The Effect of Information Level and Display Location on Pilot Performance	May-15	Paper
UAS-NAS Part Task 5 Detect and Avoid Display Evaluation Primary Results	May-15	Briefing



FY15 Project Deliverables



Project Phase 2 Technical Challenge Deliverables – HSI Continued		Date	Type of Deliverable
UAS-NAS DAA Display Evaluation in Support of SC-228 MOPS Development		Jun-15	Briefing
An examination of UAS Pilots Interaction with ATC while responding to DAA Conflicts		Jun-15	Paper
Project Phase 2 Technical Challenge Deliverables – ITE		Date	Type of Deliverable
RUMS- Real-time Visualization and Evaluation of Live Virtual, Constructive Simulation Data		Jan-15	Paper
Message Latency Characterization of a Distributed Live, Virtual, Constructive Simulation Environment		Jan-15	Paper
IHITL Test Environment Report		Mar-15	Report
Project Overview and A distributed environment for testing UAS concepts		May-15	Briefing
FT3 Test Plan - Rev E		Jul-15	Report
FT4 Test Requirements		Aug-15	Report
Project Phase 2 Technical Challenge Deliverables – Non-TC Certification		Date	Type of Deliverable
Mock Type Certification Basis for an Unmanned Rotorcraft for Aerial Application Operations		Mar-15	Paper
A Case Study for Assured Containment		May-15	Paper
Mock Certification Basis for an Unmanned Rotorcraft for Precision Agricultural Spraying		Sep-15	Paper
Project Phase 2 Technical Challenge Deliverables – Non-TC sUAS		Date	Type of Deliverable
sUAS Flight Experiments for Great Dismal Swamp Fire Detection		Dec-14	Paper



Technology Transfer Coordination (UAS-NAS to Stakeholder)



Monthly/Quarterly Coordination

Daily/Weekly Coordination

• SC-228

Stakeholder
Working
Groups

UAS TWP
Integrated
Events

- Sub WG Planning
- Key Issues Resolution
- Technical Exchange
- Briefings

- SC-228
- OSD SAA SARP
- FAA UAS Int. Office

Stakeholder
Face to Face
Meetings

- Cross WG Planning
- Key Issues Resolution
- Results Validation
- Briefings

Annual Coordination

- SC-228
- OSD SAA SARP
- FAA UAS Integration Office
- ITU-R

Stakeholder &
Project Annual
Meetings

- Strategic Planning
- Project Annual Meetings
- Professional Annual Meetings
- Final Reports/Presentations

RTCA SC-228

- Baseline PRD Content
- Initial Tech Transfer Briefings
- Final Reports

FAA

- Test Plans
- Final Reports

OSD SAA SARP

- Research Findings

ITU-R

- Spectrum Analysis

Formal UAS-NAS
Project
Deliverables to
Stakeholders

Formal Stakeholder
Deliverables
Influence
UAS-NAS

• Transfer Method

- Publicly releasable material: NASA ARMD Website
- Controlled data, e.g. ITAR: Secure email/server/website

RTCA SC-228

- White Papers
- Preliminary & Final MOPS

FAA

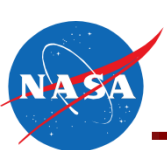
- Integration Road Maps
- Rules and Regulations

OSD SAA SARP

- Recommendations

ITU-R

- Authorization



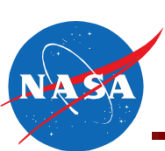
Project Office



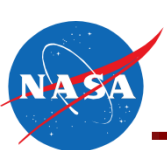
Name	FY2014				FY2015				FY2016			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Project Level												
Comprehensive Reports									◆		◆	★
API								★				★
RTCA SC-228 MOPS												
SC-228 DAA MOPS	◆							★				★
SC-228 C2 MOPS							★					★
★ API ★ L1 Program (IASP) ◆ L2 Project												

Green Status Line Date 9/30/15

Current Active Collaborations/Partnerships Status – FAA Test Sites



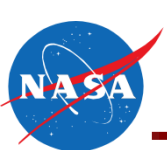
Area	FAA Test Site	Partner POCs	Agreement In Place	In Execution	Collaboration/ Partnership Role
TC-ITE	University of Alaska Fairbanks	Ro Bailey	✓ Contract	✓	Support of Task 1, UTM and support of Task 2. LVC-DE efforts
TC-ITE	State of Nevada	Thomas Wilczek	✓ Contract	✓	Support of Task 1, UTM and support of Task 2. LVC-DE efforts
TC-ITE	New York – Griffiss UAS Test Site	Chad Lawrence	✓ Contract	✓	Support of Task 1, UTM and support of Task 2. LVC-DE efforts
TC-ITE	North Dakota – Northern Plains Test Site	Robert Becklund	✓ Contract	✓	Support of Task 1, UTM and support of Task 2. LVC-DE efforts
TC-ITE	Texas A&M University	Dr. Luis Cifuentes	✓ Contract	✓	Support of Task 1, UTM and support of Task 2. LVC-DE efforts
TC-ITE	Virginia Tech	John Rudd	✓ Contract	✓	Support of Task 1, UTM and support of Task 2. LVC-DE efforts



Acronym List



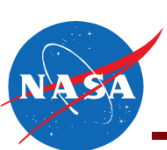
AA	Associate Administrator
ACAS	Airborne Collision Avoidance System
ACES	Airspace Concept Evaluation System
ADS-B	Automatic Dependent Surveillance Broadcast
AFRC	Armstrong Flight Research Center
AFRL	Air Force Research Lab
AFSRB	Airworthiness and Flight Safety Review Board
AIAA	American Institute of Aeronautics and Astronautics
AOSP	Airspace Operations and Safety Program
APG/I	Annual Performance Goal/Indicator
ARC	Ames Research Center/Aviation Rule Making Committee
ARD	Aeronautics Research Director
ARMED	Aeronautics Research Mission Directorate
ASRS	Aviation Safety Reporting System
ATC	Air Traffic Controller
ATO	Air Traffic Organization-FAA Organization
ATOL	Air Traffic Operations Lab
AUVSI	Association for Unmanned Vehicle Systems International
BLOS	Beyond Line of Sight
BVLOS	Beyond Visual Line of Sight
C2	Command and Control
CA	Collision Avoidance
CAS	Collision Avoidance System
CAT	Collision Avoidance Threshold



Acronym List



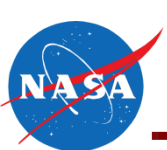
CDP	Content Decision Process
CDR	Critical Design Review
CIO	Chief Information Officer
CM	Change Management or Contingency Management
CMC	Center Management Council
CNPC	Control and Non-Payload Communications
COA	Certificate of Waiver or Authorization
COE	Center of Excellence
ConOps	Concept of Operations
CPA	Closest Point of Approach
CPDS	Conflict Prediction and Display System
CR	Change Request
CRM	Continuous Risk Management
CSD	Cockpit Situation Display
CSUN	Cal State University Northridge
CTD	Concepts and Technology Development Project
DAA	Detect and Avoid
DAIDALUS	Detect and Avoid Alerting Logic for Unmanned Systems
DER	Designated Engineering Representative
DoD	Department of Defense
DPM	Deputy Project Manager
DPMf	Department PM for
EAFB	Edwards Air Force Base
EIP	Early Implementation Plan
EL	Elevation



Acronym List



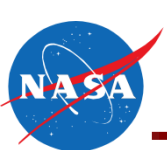
EO	Electro Optical
ERT	Engineering Review Team
ExCom	UAS Executive Committee
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulations
FL	Flight Level
FRR	Flight Readiness Review
FSS	Fixed Satellite Service
FT	Flight Test
FTE	Full Time Equivalent
FY	Fiscal Year
GA	General Aviation
GA-ASI	General Atomics Aeronautical Systems Inc.
GCS	Ground Control Station
GDS	Great Dismal Swamp
GRC	Glenn Research Center
GSN	Goal Structuring Notation
HCII	Human Computer Interaction International
HF	Human Factors
HITL	Human-In-The-Loop
HLA	High Level Architecture
HMD	Horizontal Miss Distance
HSI	Human Systems Integration Subproject
IAA	Inter-Agency Agreement



Acronym List



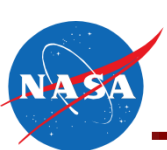
IAI	Intelligent Automation Inc.
IASP	Integrated Aviation Systems Program
ICAO	International Civil Aviation Organization
ICAST	Inter Center Autonomy Study Team
IFR	Instrument Flight Rules
IH	In House
IHITL	Integrated Human-In-The-Loop
IMS	Integrated Master Schedule
IO	Integration Office
IPO	Inter-agency Planning Office
IR	Infrared
IRP	Independent Review Panel
ITAR	International Traffic in Arms Regulations
IT&E	Integrated Test and Evaluation Subproject
ITU-R	International Telecommunication Union-Radiocommunication Sector
KDP	Key Decision Point
L1	Level 1
L2	Level 2
LaRC	Langley Research Center
LOS	Line of Sight
LSTAR	Lightweight Surveillance and Target Acquisition Radar
LSUASC	Lone Star UAS Center of Excellence
LVC	Live Virtual Constructive
LVC-DE	Live Virtual Constructive Distributed Environment



Acronym List



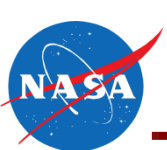
MACS	Multi-Aircraft Control System
MIPR	Military Interdepartmental Purchase Request
MIT/LL	Massachusetts Institute of Technology Lincoln Labs
MOA	Memorandum of Agreement/Methods of Assessment
MOCC	Mobile Operations Control Center
MOE	Meeting of Experts
MOPS	Minimum Operational Performance Standard
MR	Measured Response
MRB	Management Review Board
MS&A	Modeling, Simulation, and Analysis
MUSIM	Multiple UAS Simulation
NAS	National Airspace System
NATO	North Atlantic Treaty Organization
NRA	NASA Research Announcement
NUANCE	Nevada Unmanned, Autonomous, and NextGen Collaborative Environment
OCFO	Office of the Chief Financial Officer
OPNET	OPNET Technologies
OSD	Office of the Secretary of Defense
P1	Phase 1
P2	Phase 2
PDR	Preliminary Design Review
PE/Co-PE	Project Engineer/Co-Project Engineer
PI	Progress Indicator
PM	Program Manager or Project Manager
PMT	Project Management Tool



Acronym List



PO	Project Office
PPBE	Planning Programming Budgeting and Execution
PRD	Project Requirements Document
PRP	Performance Review Panel
PT	Part Task Simulation
R&D	Research and Development
RA	Resolution Advisory
RFI	Request for Information
RFP	Request for Proposal
RGCS	Research GCS
SA	Situational Awareness/Separation Assurance
SAA	Sense and Avoid/Space Act Agreement
SARP	Science and Research Panel
SASO	Safe, Autonomous Systems Operations
SBIR	Small Business Innovative Research
SC	Special Committee
SE	Systems Engineering
SMART NAS	Shadow Mode Assessment using Realistic Technologies for the National Airspace System
SME	Subject Matter Expert
SMP	Schedule Management Plan
SP	Schedule Package
SRR	System Requirements Review
SS	Self-Separation
SSG	Senior Steering Group
SSI	Separation Assurance/Sense and Avoid Interoperability Subproject



Acronym List



SST	Self-Separation Threshold
SSV	Self-Separation Volume
SUA	Special Use Airspace
sUAS	small Unmanned Aircraft System
SWAP	Size Weight And Power
TASATS	Traffic Advisory and Safety Alerting Threshold Simulation
TC	Technical Challenges
TCAS	Traffic Alert and Collision Avoidance System
ToR	Terms of Reference
TPWG	Test Plan Working Group
TRACON	Terminal Radar Approach Control Facilities
TWP	Technical Work Package
UA	Unmanned Aircraft
UAS	Unmanned Aircraft Systems
UAV	Unmanned Aircraft Vehicle
UTM	UAS Traffic Management
V&V	Verification and Validation
VFR	Visual Flight Rules
VSCS	Vigilant Spirit Control Station
WBS	Work Breakdown Structure
WG	Working Group
WJHTC	William J Hughes Technical Center
WRC	World Radio Conference
WYE	Work Year Equivalent

Goal: Provide research findings to reduce technical barriers associated with integrating Unmanned Aircraft Systems (UAS) into the National Airspace System (NAS) utilizing integrated system level tests in a relevant environment



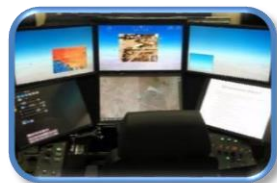
Sense and Avoid (SAA) Performance Standards

- Developed algorithms to assist UAS pilots to remain well clear of traffic.
 - Use simulation and flight test to assess algorithm performance.



Command and Control (C2) Performance Standards

- Developed Control Non-Payload Communications (CNPC) system for C2 and voice communications.
 - Use simulation, ground and flight test to assess CNPC performance.



Human Systems Integration (HSI)

- Developed prototype ground control station (GCS) and displays to examine human factors components of SAA & C2.
 - Use simulation and flight test to develop GCS guidelines.



Integrated Test & Evaluation (IT&E)

- Developed Live Virtual Constructive (LVC) test environment
 - Execute relevant environment testing to gather SAA, C2, and HSI research data.

- RTCA SC-228 developing Minimum Operational Performance Standards (MOPS). Expected release in summer 2016. Project research supports MOPS development
 - DAA: MOPS for transitioning of a UAS to and from Class A or special use airspace, traversing Class D and E, and perhaps Class G airspace.
 - C2: MOPS for C2 Data Link using L-Band Terrestrial and C-Band Terrestrial data links

